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REPORT

OF THE

SEVENTY-THIRD MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

SOUTHPORT IN SEPTEMBER 1903.

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OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

THE ASSOCIATION contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

LIFE MEMBERS shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

ANNUAL SUBSCRIBERS shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive

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gratuitously the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*; but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.
   New Life Members who have paid Ten Pounds as a composition.
   Annual Members *who have not intermitted* their Annual Subscription.
2. *At reduced or Members' Price*, viz., two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.
   Annual Members who have intermitted their Annual Subscription.
   Associates for the year. [Privilege confined to the volume for that year only.]
3. Members may purchase (for the purpose of completing their sets) any of the volumes of the Reports of the Association up to 1874, *of which more than* 15 *copies remain*, at 2*s.* 6*d.* per volume.[1]

Application to be made at the Office of the Association.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

[1] A few complete sets, 1831 to 1874, are on sale at £10 the set.

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Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee not less than two years in advance [1]; and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

Class A. Permanent Members.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant General Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

Class B. Temporary Members.[2]

1. Delegates nominated by the Corresponding Societies under the conditions hereinafter explained. *Claims under this Rule to be sent to the Assistant General Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organising Sectional Committees.[3]

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to exercise the functions of Sectional Committees until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organising Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections,[4] and of preparing Reports

[1] Revised by the General Committee, Liverpool, 1896.
[2] Revised, Montreal, 1884.
[3] Passed, Edinburgh, 1871, revised, Dover, 1899.
[4] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which

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thereon, and on the order in which it is desirable that they should be read. The Sectional Presidents of former years are *ex officio* members of the Organising Sectional Committees.[1]

An Organising Committee may also hold such preliminary meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 2 P.M., to appoint members of the Sectional Committee.[2]

Constitution of the Sectional Committees.[3]

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section, who will be appointed by the General Committee at 4 P.M., and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and appoint the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. Any Member who has intimated the intention of attending the Meeting, and who has already served upon a Committee of a Section, is eligible for election as a Member of the Committee of that Section at its first meeting.[4] The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday, and on the following Thursday, Friday, Saturday,[5] Monday, and Tuesday, for the objects stated in the Rules of the Association. The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and the Sectional Committee except for Saturday.[6]

The business is to be conducted in the following manner:—

1. The President shall call on the Secretary to read the minutes of the previous Meeting of the Committee.

they are to be read, are now as far as possible determined by Organising Committees for the several Sections *before the beginning of the Meeting*. It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each author should prepare an Abstract of his Memoir of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before....., addressed to the General Secretaries, at the office of the Association. 'For Section.....' If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. three complete weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Assistant General Secretary *before the conclusion of the Meeting*.

[1] Sheffield, 1879. [2] Swansea, 1880, revised, Dover, 1899.
[3] Edinburgh, 1871, revised, Dover, 1899. [4] Glasgow, 1901.
[5] The meeting on Saturday is optional, Southport, 1883. [6] Nottingham, 1893.

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2. No paper shall be read until it has been formally accepted by the Committee of the Section, and entered on the minutes accordingly.
3. Papers which have been reported on unfavourably by the Organising Committees shall not be brought before the Sectional Committees.[1]

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and printed in the last volume of the Report. He will next proceed to read the Report of the Organising Committee.[2] The list of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed.[2] At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings, to the Assistant General Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xxxi), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association, and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that all Members of the Committee should be named, and

[1] Plymouth, 1877. [2] Edinburgh, 1871.

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one of them appointed to act as Chairman, who shall have notified personally or in writing his willingness to accept the office, the Chairman to have the responsibility of receiving and disbursing the grant (if any has been made) and securing the presentation of the report in due time; and, further, it is expedient that one of the members should be appointed to act as Secretary, for ensuring attention to business.

That it is desirable that the number of Members appointed to serve on a Committee should be as small as is consistent with its efficient working.

That a tabular list of the Committees appointed on the recommendation of each Section should be sent each year to the Recorders of the several Sections, to enable them to fill in the statement whether the several Committees appointed on the recommendation of their respective Sections had presented their reports.

That on the proposal to recommend the appointment of a Committee for a special object of science having been adopted by the Sectional Committee, the number of Members of such Committee be then fixed, but that the Members to serve on such Committee be nominated and selected by the Sectional Committee at a subsequent meeting.[1]

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant General Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must first be sanctioned by the Committee of that Section before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

Notices regarding Grants of Money.[2]

1. No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the Rules of the Association.
2. In grants of money to Committees the Association does not contemplate the payment of personal expenses to the Members.
3. Committees to which grants of money are entrusted by the Association for the prosecution of particular Researches in Science are appointed for one year only. If the work of a Committee cannot be completed in the year, and if the Sectional Committee desire the work to be continued, application for the reappointment of the Committee for another year must be made at the next meeting of the Association.
4. Each Committee is required to present a Report, whether final or interim, at the next meeting of the Association after their appointment or reappointment. Interim Reports must be submitted in writing, though not necessarily for publication.

[1] Revised by the General Committee, Bath, 1888.
[2] Revised by the General Committee at Ipswich, 1895.

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5. In each Committee the Chairman is the only person entitled to call on the Treasurer, Professor G. Carey Foster, F.R.S., for such portion of the sums granted as may from time to time be required.
6. Grants of money sanctioned at a meeting of the Association expire on June 30 following. The Treasurer is not authorised after that date to allow any claims on account of such grants.
7. The Chairman of a Committee must, before the meeting of the Association next following after the appointment or reappointment of the Committee, forward to the Treasurer a statement of the sums which have been received and expended, with vouchers. The Chairman must also return the balance of the grant, if any, which has been received and not spent; or, if further expenditure is contemplated, he must apply for leave to retain the balance.
8. When application is made for a Committee to be reappointed, and to retain the balance of a former grant which is in the hands of the Chairman, and also to receive a further grant, the amount of such further grant is to be estimated as being additional to, and not inclusive of, the balance proposed to be retained.
9. The Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such report has been received.
10. Members and Committees who may be entrusted with sums of money for collecting specimens of any description are requested to reserve the specimens so obtained to be dealt with by authority of the Council.
11. Committees are requested to furnish a list of any apparatus which may have been purchased out of a grant made by the Association, and to state whether the apparatus will be useful for continuing the research in question, or for other scientific purposes.
12. All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association when not employed in scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation shortly before the meeting commences. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At the time appointed the Chair will be taken,[1] and the reading of communications, in the order previously made public, commenced.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

[1] The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and of the Sectional Committee, except for Saturday.

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A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1. To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.
2. To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant General Secretary.
3. Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the Official Programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

The *ex officio* members of the Committee of Recommendations are the President and Vice-Presidents of the Meeting, the General and Assistant-General Secretaries, the General Treasurer, the Trustees, and the Presidents of the Association in former years.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

All proposals for establishing new Sections, or altering the titles of Sections, or for any other change in the constitutional forms and fundamental rules of the Association, shall be referred to the Committee of Recommendations for a report.[1]

If the President of a Section is unable to attend a meeting of the Committee of Recommendations, the Sectional Committee shall be authorised to appoint a Vice-President, or, failing a Vice-President, some other member of the Committee, to attend in his place, due notice of the appointment being sent to the Assistant General Secretary.[2]

[1] Passed by the General Committee at Birmingham, 1865.
[2] Passed by the General Committee at Leeds, 1890.

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Corresponding Societies.[1]

1. Any Society is eligible to be placed on the List of Corresponding Societies of the Association which undertakes local scientific investigations, and publishes notices of the results.

2. Application may be made by any Society to be placed on the List of Corresponding Societies. Applications must be addressed to the Assistant General Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

3. A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

4. Every Corresponding Society shall return each year, on or before the 1st of June, to the Assistant General Secretary of the Association, a schedule, properly filled up, which will be issued by him, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies Committee.

5. There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

6. A Corresponding Society shall have the right to nominate any one of its members, who is also a Member of the Association, as its delegate to the Annual Meeting of the Association, who shall be for the time a Member of the General Committee.

Conference of Delegates of Corresponding Societies.

7. The Conference of Delegates of Corresponding Societies is empowered to send recommendations to the Committee of Recommendations for their consideration, and for report to the General Committee.

8. The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council, and appointed by the General Committee, and of which the members of the Corresponding Societies Committee shall be *ex officio* members.

9. The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the meetings.

10.[2] The Organising Committees of each Section shall be instructed to

[1] Passed by the General Committee, 1884.
[2] Revised by the General Committee, 1903.

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transmit to the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

11. It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

(1) The Council shall consist of[1]

1. The Trustees.
2. The past Presidents.
3. The President and Vice-Presidents for the time being.
4. The President and Vice-Presidents elect.
5. The past and present General Treasurers, General and Assistant General Secretaries.
6. The Local Treasurer and Secretaries for the ensuing Meeting.
7. Ordinary Members.

(2) The Ordinary Members shall be elected annually from the General Committee.

[1] Passed by the General Committee at Belfast, 1874.

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(3) There shall be not more than twenty-five Ordinary Members, of whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.

(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year —observing (as nearly as possible) the proportion of three by seniority to two by least attendance.

(5) The Council shall submit to the General Committee in their Annual Report the names of the Members of the General Committee whom they recommend for election as Members of Council.

(6) The Election shall take place at the same time as that of the Officers of the Association.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

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Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S., F.R.S.E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S., F.R.S.E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S., F.R.S.E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Rev. T. R. Robinson, D.D. The Very Rev. Principal Macfarlane The Earl of Dartmouth John Corrie, Esq., F.R.S.	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.

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The MARQUIS OF BREADALBANE, F.R.S. ..... GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c..... PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P..... Sir C. Lemon, Bart. ..... Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. ..... MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S.... Sir Benjamin Heywood, Bart.....	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. ..... CORK, August 17, 1843.	The Earl of Listowel. Viscount Adare..... Sir W. R. Hamilton, Pres. R.I.A. ..... Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Kelcher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. ..... YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S..... The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S..... Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. ..... CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich ..... Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. ..... G. B. Airy, Esq., M.A., D.C.L., F.R.S..... The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L..... Lord Ashburton, D.C.L. Viscount Palmerston, M.P. ..... Right Hon. Charles Shaw Lefevre, M.P. ..... Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. ..... The Lord Bishop of Oxford, F.R.S..... Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S....	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford..... OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. ..... The Vice-Chancellor of the University ..... Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S.... Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.

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PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. **Viscount Adare**, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	**Matthew Moggridge, Esq.** **D. Nicol, Esq., M.D.**
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	**Captain Tindal, R.N.** **William Wills, Esq.** **Bell Fletcher, Esq., M.D.** **James Chance, Esq.**
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	**Rev. Professor Kelland M.A., F.R.S., F.R.S.E.** **Professor Balfour, M.D., F.R.S.E., F.L.S.** **James Tod, Esq., F.R.S.E.**
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. **The Lord Bishop of Norwich** Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. **Sir William F. F. Middleton, Bart.** J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	**Charles May, Esq., F.R.A.S.** **Dillwyn Sims, Esq.** **George Arthur Biddell, Esq.** **George Ransome, Esq., F.L.S.**
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	**The Earl** of Enniskillen, D.C.L., F.R.S. **The Earl** of Rosse, Pres. R.S., M.R.I.A. **Sir Henry** T. De la Beche, F.R.S. **Rev. Edward** Hincks, D.D., M.R.I.A. **Rev. P.** S. Henry, D.D., Pres. Queen's College, Belfast **Rev. T.** R. Robinson, D.D., Pres. R.I.A., F.R.A.S. **Professor** G. G. Stokes, F.R.S. Professor Stevelly, **LL.D.**	**W. J. C. Allen, Esq.** **William M'Gee, Esq., M.D.** **Professor W. P. Wilson.**
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	**Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society.** **Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.**
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S., F.R.S.E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	**Joseph Dickinson, Esq., M.D., F.R.S** **Thomas Inman, Esq., M.D.**

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The DUKE OF ARGYLL, F.R.S., F.G.S. **GLASGOW, September 12, 1855.**	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S., F.R.S.E. Thomas Graham, Esq., M.A., F.R.S. Professor William Thomson, M.A., F.R.S.	**John Strang, Esq., LL.D.** **Professor Thomas Anderson, M.D.** **William Gourlie, Esq.**
CHARLES G. B. DAUBENY, Esq., M.D., LL.D., F.R.S., **Professor of Botany in the University of Oxford.** **CHELTENHAM, August 6, 1856.**	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. **Walter Crum, Esq., F.R.S.** **The Rev. Francis Close, M.A.**	**Capt. Robinson, R.A.** **Richard Beamish, Esq., F.R.S.** **John West Hugell, Esq.**
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S., F.R.S.E., V.P.R.I.A. **DUBLIN, August 26, 1857.**	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S. **Lord Talbot de Malahide**	**Lundy E. Foote, Esq.** **Rev. Professor Jellett, F.T.C.D.** **W. Neilson Hancock, Esq., LL.D.**
RICHARD OWEN, Esq., M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. **LEEDS, September 22, 1858.**	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	**Rev. Thomas Hincks, B.A.** **W. Sykes Ward, Esq., F.C.S.** **Thomas Wilson, Esq., M.A.**
HIS ROYAL HIGHNESS THE PRINCE CONSORT.. **ABERDEEN, September 14, 1859.**	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	**Professor J. Nicol, F.R.S.E., F.G.S.** **Professor Fuller, M.A.** **John F. White, Esq.**
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S.. **OXFORD, June 27, 1860.**	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford	**George Rolleston, Esq., M.D., F.L.S.** **H. J. S. Smith, Esq., M.A., F.O.S.** **George Griffith, Esq., M.A., F.C.S.**

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PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. ..... MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. ..... The Lord Stanley, M.P., D.C.L., F.R.G.S. ..... The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. ..... Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. ..... Sir Benjamin Heywood, Bart., F.R.S. ..... Thomas Bazley, Esq., M.P. ..... James Aspinall Turner, Esq., M.P. ..... James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester ..... Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. ..... Joseph Whitworth, Esq., F.R.S., M.Inst.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge ..... CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge ..... The Very Rev. Harvey Goodwin, D.D., Dean of Ely ..... The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. ..... The Rev. J. Challis, M.A., F.R.S. ..... G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal ..... Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. ..... Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. ..... NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. ..... Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. ..... Hugh Taylor, Esq., Chairman of the Coal Trade ..... Isaac Lowthian Bell, Esq., Mayor of Newcastle ..... Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers ..... Rev. Temple Chevallier, B.D., F.R.A.S. ..... William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. ..... BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire ..... The Most Noble the Marquis of Bath ..... The Right Hon. Earl Nelson ..... The Right Hon. Lord Portman ..... The Very Rev. the Dean of Hereford ..... The Venerable the Archdeacon of Bath ..... W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. ..... A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. ..... W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford ..... BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley ..... The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire ..... The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire .. The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. ..... The Right Rev. the Lord Bishop of Worcester ..... The Right Hon. C. B. Adderley, M.P. ..... William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. ..... J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

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WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. **NOTTINGHAM, August 22, 1866.**	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	**Dr. Robertson.** **Edward J. Lowe, Esq., F.R.A.S., F.L.S.** **The Rev. J. F. M'Callan, M.A.**
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. **DUNDEE, September 4, 1867.**	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	**J. Henderson, jun., Esq.** **John Austin Lake Gloag, Esq.** **Patrick Anderson, Esq.**
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. **NORWICH, August 19, 1868.**	The Right Hon. the Earl of **Leicester, Lord-Lieutenant of Norfolk** Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	**Dr. Donald Dalrymple.** **Rev. Joseph Crompton, M.A.** **Rev. Canon Hinds Howell.**
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. **EXETER, August 18, 1869.**	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	**Henry S. Ellis, Esq., F.R.A.S.** **John C. Bowring, Esq.** **The Rev. R. Kirwan.**
PROFESSOR T. H. HUXLEY, LL.D., F.R.S., F.G.S. **LIVERPOOL, September 14, 1870.**	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	**Rev. W. Banister.** **Reginald Harrison, Esq.** **Rev. Henry H. Higgins, M.A.** **Rev. Dr. A. Hume, F.S.A.**

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PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S., F.R.S.E. ..... EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. ..... The Right Hon. the Lord Provost of Edinburgh ..... The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland .. Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh ..... Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. ..... Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. ..... Dr. Lyon Playfair, C.B., M.P., F.R.S. ..... Professor Christison, M.D., D.C.L., Pres. R.S.E. ..... Professor Balfour, F.R.S., F.R.S.E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. .. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk ..... His Grace the Duke of Richmond, K.G., P.C., D.C.L. ..... His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. ..... Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. ..... Dr. Sharpey, LL.D., Sec. R.S., F.L.S. ..... Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. ..... BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. ..... The Right Hon. Lord Houghton, D.C.L., F.R.S. ..... The Right Hon. W. E. Forster, M.P. ..... The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. .. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S. .	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. ..... BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. ..... The Right Hon. the Earl of Rosse, F.R.S. ..... Sir Richard Wallace, Bart., M.P. ..... The Rev. Dr. Henry. Dr. Andrews, F.R.S. ..... The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M.Inst.C.E., F.R.S., F.G.S. .. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. ..... The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. .... The Mayor of Bristol ..... Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. ..... W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. ..... GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S., F.R.S.E., F.G.S. .. The Hon. the Lord Provost of Glasgow ..... Sir William Stirling Maxwell, Bart., M.A., M.P. ..... Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S., F.R.S.E. Professor Allen Thomson, M.D., LL.D., F.R.S., F.R.S.E. ..... Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. ..... James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.

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PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S., F.R.S.E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.B., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S., F.R.S.E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S. L. & E. Professor Allman, M.D., LL.D., F.R.S. L. & E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.
C. W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John B. Le Feuvre, Esq. Morris Miles, Esq.

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ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge **SOUTHPORT, September 19, 1883.**	The Right Hon. the **Earl of Derby, M.A., LL.D.**, F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	**J. H. Ellis, Esq.** **Dr. Vernon.** **T. W. Willis, Esq.**
The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. **MONTREAL, August 27, 1884.**	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., F.R.S. L. & E. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. The Hon. Dr. Chauveau Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. **ABERDEEN, September 9, 1885.**	**His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen** The Right Hon. the Earl of Aberdeen, LL.D., **Lord-Lieutenant of Aberdeenshire** The Right Hon. the Earl of Crawford and Balcarres, **M.A., LL.D.**, F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S., F.R.S.E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., **Pres. Z.S., F.G.S.**, Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	**J. W. Crombie, Esq., M.A.** **Angus Fraser, Esq., M.A., M.D., F.C.S.** **Professor G. Pirie, M.A.**
SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada **BIRMINGHAM, September 1, 1886.**	**The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire.** **The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire.** **The Right Hon. Lord Norton, K.C.M.G.** **The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire** **The Right Rev. the Lord Bishop of Worcester, D.D.** **Thomas Martineau, Esq., Mayor of Birmingham** **Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S.** **Professor W. A. Tilden, D.Sc., F.R.S., F.C.S.** **Rev. A. R. Vardy, M.A.** **Rev. H. W. Watson, D.Sc., F.R.S.**	**J. Barham Carslake, Esq.** **Rev. H. W. Crosskey, LL.D., F.G.S.** **Charles J. Hart, Esq.**

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SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. **MANCHESTER, August 31, 1887.**	**His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S.** The Right Hon. the Earl of Derby, K.G., M.A., **LL.D., F.R.S., F.R.G.S.** The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., **M.D.**, F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., **F.R.S.E., F.C.S.**	F. J. Faraday, Esq., **F.L.S., F.S.S.** Charles Hopkinson, Esq., **B.Sc.** Professor A. Milnes **Marshall, M.A., M.D.,** D.Sc., F.R.S. Professor A. H. Young, **M.B., F.R.C.S.**
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. **BATH, September 5, 1888.**	The Right Hon. **the Earl of Cork and Orrery, Lord-Lieutenant of Somerset** The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop **of Bath and Wells, D.D.** The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. **R.S., F.L.S., F.C.S.** W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. — Colonel **R. P. Laurie, C.B., M.P.** E. R. Wodehouse, Esq., M.P. — Jerom Murch, Esq., J.P., D.L.	**W. Pumphrey, Esq.** **J. L. Stothert, Esq., M.Inst.C.E.** **B. H. Watts, Esq.**
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum **NEWCASTLE-UPON-TYNE, September 11, 1889.**	**His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland** **The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham** **The Right Hon. the Earl of Ravensworth** **The Right Rev. the Lord Bishop of Newcastle, D.D.** The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., **F.R.S.** The Right Hon. John Morley, M.P., LL.D. **The Very Rev. the Warden of the University of Durham, D.D.** **The Right Worshipful the Mayor of Newcastle** **The Worshipful the Mayor of Gateshead** **Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E.** **Sir Charles Mark Palmer, Bart., M.P.**	**Professor P. Phillips Bedson, D.Sc., F.C.S.** **Professor J. Herman Merivale, M.A.**
SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., P.P.C.S., Hon.M.Inst.C.E. **LEEDS, September 3, 1890.**	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., **F.R.S.** The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. — The Mayor of Leeds Sir James Kitson Bart., M.Inst.C.E. — Sir Andrew Fairbairn, M.A.	**J. Rawlinson Ford, Esq.** Sydney Lupton, Esq., M.A. **Professor L. C. Miall, F.L.S., F.G.S.** **Professor A. Smithells, B.Sc.**

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WILLIAM HUGGINS, Esq., D.C.L., LL.D., Ph.D., F.R.S., F.R.A.S., Hon. F.R.S.E. CARDIFF, August 19, 1891.	The Right Hon. Lord Windsor, Lord-Lieutenant of Glamorganshire The Most Hon. the Marquess of Bute, K.T. The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S. The Right Hon. Lord Tredegar The Right Hon. Lord Aberdare, G.C.B., F.R.S., F.R.G.S. Sir J. T. D. Llewelyn, Bart., F.Z.S. Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S., F.R.S.E., Pres.G.S. Sir Robert Ball, LL.D., F.R.S., F.R.A.S., Royal Astronomer of Ireland	R. W. Atkinson, Esq., B.Sc., F.C.S., F.I.C. Professor H. W. Lloyd Tanner, M.A., F.R.A.S.
SIR ARCHIBALD GEIKIE LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom. EDINBURGH, August 3, 1892.	The Right Hon. the Lord Provost of Edinburgh The Most Hon. the Marquess of Lothian, K.T. The Right Hon. the Earl of Rosebery, LL.D., F.R.S., F.R.S.E. The Right Hon. J. H. A. Macdonald, C.B., LL.D., F.R.S., F.R.S.E. Principal Sir William Muir, K.C.S.I., D.C.L. Professor Sir Douglas Maclagan, M.D., Pres.R.S.E. Professor Sir William Turner, F.R.S., F.R.S.E. Professor P. G. Tait, M.A., F.R.S.E. Professor A. Crum Brown, M.D., F.R.S., F.R.S.E., Pres.C.S.	Professor G. F. Armstrong, M.A., M.Inst.C.E., F.R.S.E., F.G.S. F. Grant Ogilvie, Esq., M.A., B.Sc., F.R.S.E. John Harrison, Esq.
DR. J. S. BURDON SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford. NOTTINGHAM, September 13, 1893.	His Grace the Duke of St. Albans, Lord-Lieut. of Nottinghamshire His Grace the Duke of Devonshire, K.G., Chancellor of the University of Cambridge His Grace the Duke of Portland. His Grace the Duke of Newcastle The Right Hon. Lord Belper. The Mayor of Nottingham The Right Hon. Sir W. R. Grove, F.R.S. Sir John Turney, J.P. Professor Michael Foster, M.A., Sec.R.S. W. H. Ransom, Esq., M.D., F.R.S.	Professor F. Clowes, D.Sc. Professor W. H. Heaton, M.A. Arthur Williams, Esq.
The MOST HON. THE MARQUIS OF SALISBURY, K.G., D.C.L., F.R.S., Chancellor of the University of Oxford. OXFORD, August 8, 1894.	The Right Hon. the Earl of Jersey, G.C.M.G., Lord-Lieutenant of the County of Oxford The Right Hon. Lord Wantage, K.C.B., V.C., Lord-Lieutenant of Berkshire The Right Hon. the Earl of Rosebery, K.G., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Oxford, D.D. The Right Hon. Lord Rothschild, Lord-Lieutenant of Buckinghamshire The Right Hon. Lord Kelvin, D.C.L., Pres.R.S. The Rev. the Vice-Chancellor of the University of Oxford. The Mayor of Oxford. Sir W. R. Anson, D.C.L., Warden of All Souls College Sir Bernhard Samuelson, Bart., M.P., F.R.S. Sir Henry Dyke Acland, Bart., M.D., F.R.S., Regius Professor of Medicine The Rev. B. Price, D.D., F.R.S., Sedleian Professor of Natural Philosophy Dr. J. J. Sylvester, F.R.S., Savilian Professor of Geometry.	Gilbert C. Bourne, Esq., M.A. G. C. Druce, Esq., M.A. D. H. Nagel, Esq., M.A.

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1903 **CAPTAIN SIR DOUGLAS GALTON, K.C.B., LL.D., F.R.S., F.R.G.S., F.G.S.** ..... Ipswich, September 11, 1895.	**The Most Hon. the Marquis of Bristol, M.A., Lord-Lieutenant of the County of Suffolk**	**G. H. Hewetson, Esq.**
	The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge	**S. A. Notcutt, Esq., B.A., LL.M., B.Sc.**
	The Right Hon. Lord Rayleigh, Sec.R.S., Lord-Lieutenant of Essex	**H. P. Ridley, Esq.**
	The Right Hon. Lord Gwydyr, M.A., High Steward of Ipswich	
	The Right Hon. Lord Henniker, F.S.A. The Right Hon. Lord Rendlesham	
	J. H. Bartlet, Esq., Mayor of Ipswich	
	Sir G. G. Stokes, Bart., D.C.L., F.R.S. Dr. E. Frankland, D.C.L., F.R.S.	
	Professor G. H. Darwin, M.A., F.R.S. Felix T. Cobbold, Esq., M.A.	
SIR JOSEPH LISTER, Bart., D.C.L., LL.D., President of the Royal Society ..... Liverpool, September 16, 1896.	**The Right Hon. the Earl of Derby, G.C.B., Lord Mayor of Liverpool.** ..	**Professor W. A. Herdman, F.R.S.**
	The Right Hon. the Earl of Sefton, K.G., Lord-Lieutenant of Lancashire	**Isaac C. Thompson, Esq., F.L.S.**
	Sir W. B. Forwood, J.P.	**W. R. Willink, Esq.**
	Sir Henry E. Roscoe, D.C.L., F.R.S.	
	The Principal of University College, Liverpool	
	W. Rathbone, Esq., LL.D.	
	W. Crookes, Esq., F.R.S., V.P.C.S.	
	T. H. Ismay, Esq., J.P., D.L.	
	Professor A. Liversidge, F.R.S.	
SIR JOHN EVANS, K.C.B., D.C.L., LL.D., Sc.D., Treas.R.S., F.S.A., For.Sec.G.S. ..... Toronto, August 18, 1897.	**His Excellency the Right Hon. the Earl of Aberdeen, G.C.M.G., Governor-General of the Dominion of Canada**	**Professor A. B. Macallum, M.B., Ph.D.**
	The Right Hon. Lord Rayleigh, M.A., D.C.L., F.R.S.	**R. E. Walker, Esq., F.G.S.**
	The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S., F.R.S.E.	**J. S. Willison, Esq.**
	The Hon. Sir Wilfrid Laurier, G.C.M.G., Prime Minister of the Dominion of Canada	
	His Honour the Lieutenant-Governor of the Province of Ontario.....	
	The Hon. the Premier of the Province of Ontario	
	The Hon. the Minister of Education for the Province of Ontario.....	
	The Hon. Sir Charles Tupper, Bart., G.C.M.G., C.B., LL.D......	
	The Hon. Sir Donald A. Smith, G.C.M.G., LL.D., High Commissioner for Canada	
	Sir William Dawson, C.M.G., F.R.S. The Mayor of Toronto	
	Professor J. Loudon, M.A., LL.D., President of the University of Toronto	
SIR WILLIAM CROOKES, F.R.S., V.P.C.S. ..... Bristol, September 7, 1898.	**The Right Hon. the Earl of Ducie, F.R.S., F.G.S.**	**Arthur Lee, Esq., J.P.**
	The Right Rev. the Lord Bishop of Bristol, D.D.	**Bertram Rogers, Esq., M.D.**
	The Right Hon. Sir Edward Fry, D.C.L., F.R.S., F.S.A.	
	Sir F. J. Bramwell, Bart., D.C.L., LL.D., F.R.S......	
	The Right Worshipful the Mayor of Bristol	
	The Principal of University College, Bristol	
	The Master of the Society of Merchant Venturers of Bristol	
	John Beddoe, Esq., M.D., LL.D., F.R.S......	
	Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.	

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PRESIDENTS	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR MICHAEL FOSTER, K.C.B., M.D., D.C.L., LL.D., Sec. R.S. DOVER, September 13, 1899.	His Grace the Lord Archbishop of Canterbury, D.D. The Most Hon. the Marquis of Salisbury, K.G., M.A., D.C.L., F.R.S. The Mayor of Dover The Major-General Commanding the South-Eastern District The Right Hon. A. Akers-Douglas, M.P. The Very Rev. F. W. Farrar, D.D., F.R.S., Dean of Canterbury Sir J. Norman Lockyer, K.C.B., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S., Pres. R.A.S.	E. Wollaston Knocker, Esq., C.B. W. H. Pendlebury, Esq., M.A.
PROFESSOR SIR WILLIAM TURNER, M.B., D.Sc., D.C.L., LL.D., F.R.S. BRADFORD, September 5, 1900.	The Right Hon. the Earl of Scarbrough, Lord-Lieutenant of the West Riding of Yorkshire His Grace the Duke of Devonshire, K.G., D.C.L., LL.D., F.R.S. The Most Hon. the Marquis of Ripon, K.G., G.C.S.I., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Lord Masham His Worship the Mayor of Bradford The Hon. H. E. Butler, Lord of the Manor, Bradford Sir Alexander Binnie, M.Inst.C.E., F.G.S. Professor A. W. Rücker, M.A., D.Sc., Sec.R.S. Dr. T. E. Thorpe, Sc.D., F.R.S., Pres.C.S. Principal N. Bodington, Litt.D., Vice-Chancellor of the Victoria University Professor L. C. Miall, F.R.S.	Bamsden Bacchus, Esq. J. E. Fawcett, Esq., J.P. Frederick Stevens, Esq.
PROFESSOR A. W. RÜCKER, M.A., LL.D., D.Sc., Sec.R.S. GLASGOW, September 11, 1901.	The Right Hon. the Earl of Glasgow, G.C.M.G. The Right Hon. the Lord Blythswood, LL.D., D.L. The Right Hon. the Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. Samuel Chisholm, Esq., the Hon. the Lord Provost of Glasgow Very Rev. R. Herbert Story, D.D., LL.D., Principal of the University of Glasgow Sir John Maxwell Stirling-Maxwell, Bart., M.P., D.L. Sir Andrew Noble, K.C.B., D.C.L., F.R.S. Sir Archibald Geikie, D.C.L., LL.D., F.R.S. Sir W. T. Thiselton-Dyer, K.C.M.G., C.I.E., F.R.S. James Parker Smith, Esq., M.P., D.L. John Inglis, Esq., LL.D. Professor John Cleland, M.D., LL.D., D.Sc., F.R.S.	Sir J. D. Marwick, LL.D., D.L., F.R.S.E. Professor John Young, M.D. Professor Magnus Maclean, D.Sc., F.R.S.E.

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PROFESSOR JAMES DEWAR, M.A., LL.D., D.Sc., F.R.S. BELFAST, September 10, 1902.	His Grace the Duke of Abercorn, K.G., H.M. Lieutenant of the County of Donegal The Marquis of Londonderry, K.G., H.M. Lieutenant of the City of Belfast Sir Francis Macnaghten, Bart., H.M. Lieutenant of the County of Antrim The Right Hon. the Earl of Shaftesbury, D.L. The Right Hon. the Earl of Rosse, K.P., D.C.L., LL.D., F.R.S. The Right Hon. Thomas Sinclair, D.Lit. Sir William Quartus Ewart, Bart., M.A. The Lord Mayor of Belfast The President of Queen's College, Belfast Professor E. Ray Lankester, M.A., F.R.S. Professor Peter Redfern, M.D.	John Brown, Esq., F.R.S. Godfrey W. Ferguson, Esq. Professor Maurice FitzGerald, B.A.
SIR NORMAN LOCKYER, K.C.B., LL.D., F.R.S., Correspondant de l'Institut de France SOUTHPORT, September 9, 1903.	The Right Hon. the Earl of Derby, K.G., G.C.B. The Right Hon. the Earl of Crawford and Balcarres, K.T., LL.D., F.R.S. The Right Hon. the Earl Spencer, K.G., LL.D., Chancellor of the Victoria University The Right Hon. the Earl of Sefton The Right Hon. the Earl of Lathom Sir Henry Roscoe, B.A., Ph.D., LL.D., D.C.L., F.R.S. Sir George A. Pilkington Alfred Hopkinson, Esq., LL.D., K.C., Vice-Chancellor of the Victoria University T. T. L. Scarisbrick, Esq., Mayor of Southport E. Marshall Hall, Esq., K.C., M.P. for Southport Charles H. B. Hesketh, Esq. Charles Scarisbrick, Esq., J.P. Charles Weld Blundell, Esq.	Harold Brodrick, Esq., M.A J. Ernest Jarratt, Esq.

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PRESIDENTS	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR MICHAEL FOSTER, K.C.B., M.D., D.C.L., LL.D., Sec. R.S. DOVER, September 13, 1899.	His Grace the Lord Archbishop of Canterbury, D.D. The Most Hon. the Marquis of Salisbury, K.G., M.A., D.C.L., F.R.S. The Mayor of Dover The Major-General Commanding the South-Eastern District The Right Hon. A. Akers-Douglas, M.P. The Very Rev. F. W. Farrar, D.D., F.R.S., Dean of Canterbury Sir J. Norman Lockyer, K.C.B., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S., Pres. R.A.S.	E. Wollaston Knocker, Esq., C.B. W. H. Pendlebury, Esq., M.A.
PROFESSOR SIR WILLIAM TURNER, M.B., D.Sc., D.C.L., LL.D., F.R.S. BRADFORD, September 5, 1900.	The Right Hon. the Earl of Scarbrough, Lord-Lieutenant of the West Riding of Yorkshire His Grace the Duke of Devonshire, K.G., D.C.L., LL.D., F.R.S. The Most Hon. the Marquis of Ripon, K.G., G.C.S.I., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Lord Masham His Worship the Mayor of Bradford The Hon. H. E. Butler, Lord of the Manor, Bradford Sir Alexander Binnie, M.Inst.C.E., F.G.S. Professor A. W. Rücker, M.A., D.Sc., Sec.R.S. Dr. T. E. Thorpe, Sc.D., F.R.S., Pres.C.S. Principal N. Bodington, Litt D., Vice-Chancellor of the Victoria University Professor L. C. Miall, F.R.S.	Bamsden Bacchus, Esq. J. E. Fawcett, Esq., J.P. Frederick Stevens, Esq.
PROFESSOR A. W. RÜCKER, M.A., LL.D., D.Sc., Sec.R.S. GLASGOW, September 11, 1901.	The Right Hon. the Earl of Glasgow, G.C.M.G. The Right Hon. the Lord Blythswood, LL.D., D.L. The Right Hon. the Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. Samuel Chisholm, Esq., the Hon. the Lord Provost of Glasgow Very Rev. R. Herbert Story, D.D., LL.D., Principal of the University of Glasgow Sir John Maxwell Stirling-Maxwell, Bart., M.P., D.L. Sir Andrew Noble, K.C.B., D.C.L., F.R.S. Sir Archibald Geikie, D.C.L., LL.D., F.R.S. Sir W. T. Thiselton-Dyer, K.C.M.G., C.I.E., F.R.S. James Parker Smith, Esq., M.P., D.L. John Inglis, Esq., LL.D. Professor John Cleland, M.D., LL.D., D.Sc., F.R.S.	Sir J. D. Marwick, LL.D., D.L., F.R.S.E. Professor John Young, M.D. Professor Magnus Maclean, D.Sc., F.R.S.E.

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PROFESSOR JAMES DEWAR, M.A., LL.D., D.Sc., F.R.S. **Belfast, September 10, 1902.**	His Grace the Duke of Abercorn, K.G., H.M. **Lieutenant of the County of Donegal** The Marquis of Londonderry, K.G., H.M. Lieutenant of the City of Belfast Sir Francis Macnaghten, Bart., H.M. Lieutenant of the County of Antrim The Right Hon. the Earl of Shaftesbury, D.L. The Right Hon. the Earl of Rosse, K.P., D.C.L., **LL.D., F.R.S.** The Right Hon. Thomas Sinclair, D.Litt. Sir William Quartus Ewart, Bart., M.A. The Lord Mayor of Belfast The President of Queen's College, Belfast Professor E. Ray Lankester, M.A., F.R.S. Professor Peter Redfern, M.D.	**John Brown, Esq., F.R.S.** **Godfrey W. Ferguson, Esq.** **Professor Maurice FitzGerald, B.A.**
SIR NORMAN LOCKYER, K.C.B., LL.D., F.R.S., Correspondant de l'Institut de France **Southport, September 9, 1903.**	**The Right Hon. the Earl of Derby, K.G., G.C.B.** **The Right Hon. the Earl of Crawford and Balcarres, K.T., LL.D., F.R.S.** **The Right Hon. the Earl Spencer, K.G., LL.D., Chancellor of the Victoria University** **The Right Hon. the Earl of Sefton** The Right Hon. the Earl of Lathom Sir Henry Roscoe, B.A., Ph.D., LL.D., D.C.L., F.R.S. Sir George A. Pilkington Alfred Hopkinson, Esq., LL.D., K.C., Vice-Chancellor of the Victoria University T. T. L. Scarisbrick, Esq., Mayor of Southport E. Marshall Hall, Esq., K.C., M.P. for Southport Charles H. E. Hesketh, Esq. Charles Scarisbrick, Esq., J.P. Charles Weld Blundell, Esq.	**Harold Brodrick, Esq., M.A** **J. Ernest Jarratt, Esq.**

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TRUSTEES AND GENERAL OFFICERS, 1831-1903.

TRUSTEES.

1832–70	(Sir) R. I. MURCHISON (Bart.), F.R.S.
1832–62	JOHN TAYLOR, Esq., F.R.S.
1832–39	C. BABBAGE, Esq., F.R.S.
1839–44	F. BAILY, Esq., F.R.S.
1844–58	Rev. G. PEACOCK, F.R.S.
1858–82	General E. SABINE, F.R.S.
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1872	Sir J. LUBBOCK, Bart. (now Lord AVEBURY), F.R.S.
1881–83	W. SPOTTISWOODE, Esq., Pres. R.S.
1883	Lord RAYLEIGH, F.R.S.
1883–98	Sir LYON (afterwards Lord) PLAYFAIR, F.R.S.
1898	Prof. (Sir) A. W. RÜCKER, F.R.S.

GENERAL TREASURERS.

1831	JONATHAN GRAY, Esq.
1832–62	JOHN TAYLOR, Esq., F.R.S.
1862–74	W. SPOTTISWOODE, Esq., F.R.S.
1874–91	Prof. A. W. WILLIAMSON, F.R.S.
1891–98	Prof. A. W. RÜCKER, F.R.S.
1898	Prof. G. C. FOSTER, F.R.S.

GENERAL SECRETARIES.

1832–35	Rev. W. VERNON HARCOURT, F.R.S.
1835–36	Rev. W. VERNON HARCOURT, F.R.S., and F. BAILY, Esq., F.R.S.
1836–37	Rev. W. VERNON HARCOURT, F.R.S., and R. I. MURCHISON, Esq., F.R.S.
1837–39	R. I. MURCHISON, Esq., F.R.S., and Rev. G. PEACOCK, F.R.S.
1839–45	Sir R. I. MURCHISON, F.R.S., and Major E. SABINE, F.R.S.
1845–50	Lieut.-Colonel E. SABINE, F.R.S.
1850–52	General E. SABINE, F.R.S., and J. F. ROYLE, Esq., F.R.S.
1852–53	J. F. ROYLE, Esq., F.R.S.
1853–59	General E. SABINE, F.R.S.
1859–61	Prof. R. WALKER, F.R.S.
1861–62	W. HOPKINS, Esq., F.R.S.
1862–63	W. HOPKINS, Esq., F.R.S., and Prof. J. PHILLIPS, F.R.S.
1863–65	W. HOPKINS, Esq., F.R.S., and F. GALTON, Esq., F.R.S.
1865–66	F. GALTON, Esq., F.R.S.
1866–68	F. GALTON, Esq., F.R.S., and Dr. T. A. HIRST, F.R.S.
1868–71	Dr. T. A. HIRST, F.R.S., and Dr. T. THOMSON, F.R.S.
1871–72	Dr. T. THOMSON, F.R.S., and Capt. DOUGLAS GALTON, F.R.S.
1872–76	Capt. D. GALTON, F.R.S., and Dr. MICHAEL FOSTER, F.R.S.
1876–81	Capt. D. GALTON, F.R.S., and Dr. P. L. SCLATER, F.R.S.
1881–82	Capt. D. GALTON, F.R.S., and Prof. F. M. BALFOUR, F.R.S.
1882–83	Capt. DOUGLAS GALTON, F.R.S.
1883–95	Sir DOUGLAS GALTON, F.R.S., and A. G. VERNON HARCOURT, Esq., F.R.S.
1895–97	A. G. VERNON HARCOURT, Esq., F.R.S., and Prof. E. A. SCHÄFER, F.R.S.
1897–1900	Prof. SCHÄFER, F.R.S., and Sir W. C. ROBERTS-AUSTEN, F.R.S.
1900–02	Sir W. C. ROBERTS-AUSTEN, F.R.S., and Dr. D. H. SCOTT, F.R.S.
1902–03	Dr. D. H. SCOTT, F.R.S., and Major P. A. MACMAHON, F.R.S.
1903	Major P. A. MACMAHON, F.R.S., and Prof. W. A. HERDMAN, F.R.S.

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1831	JOHN PHILLIPS, Esq., *Secretary.*
1832	Prof. J. D. FORBES, *Acting Secretary.*
1832–62	Prof. JOHN PHILLIPS, F.R.S.
1862–78	G. GRIFFITH, Esq., M.A.
1878–80	J. E. H. GORDON, Esq., B.A., *Assistant Secretary.*
1881	G. GRIFFITH, Esq., M.A., *Acting Secretary.*
1881–85	Prof. T. G. BONNEY, F.R.S., *Secretary.*
1885–90	A. T. ATCHISON, Esq., M.A., *Secretary.*
1890	G. GRIFFITH, Esq., M.A., *Acting Secretary.*
1890–1902	G. GRIFFITH, Esq., M.A.
1902	J. G. GARSON, Esq., M.D.

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Presidents and Secretaries of the Sections of the Association.

Date and Place	Presidents	Secretaries
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford.....	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin.....	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol.....	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool...	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S....	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow ...	Prof. Forbes, F.R.S.....	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.....	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork.....	Prof. M'Culloch, M.R.I.A. ...	J. Nott, Prof. Stevelly.
1844. York.....	The Earl of Rosse, F.R.S. ...	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford.....	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea ...	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.....	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich ...	Rev. W. Whewell, D.D., F.R.S.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast.....	Prof. W. Thomson, M.A., F.R.S., F.R.S.E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull.....	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool...	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow ...	Rev. Prof. Kelland, M.A., F.R.S., F.R.S.E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin.....	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.

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Date and Place	Presidents	Secretaries
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.
1860. Oxford.....	Rev. B. Price, M.A., F.R.S....	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath.....	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee ...	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton ...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford ...	Prof. H. J. S. Smith, F.R.S. .	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast.....	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol.....	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley. Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin.....	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1880. Swansea ...	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1881. York.....	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	Prof. W. E. Ayrton, Dr. O. J. Lodge D. MacAlister, Rev. W. Routh.
1882. Southampton.	Rt. Hon. Prof. Lord Rayleigh, M.A., F.R.S.	W. M. Hicks, Dr. O. J. Lodge, D. MacAlister, Rev. G. Richardson.
1883. Southport	Prof. O. Henrici, Ph.D., F.R.S.	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Prof. R. C. Rowe.
1884. Montreal ...	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	C. Carpmael, W. M. Hicks, A. Johnson, O. J. Lodge, D. MacAlister.

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Date and Place	Presidents	Secretaries
1885. Aberdeen...	Prof. G. Chrystal, M.A., F.R.S.E.	R. E. Baynes, R. T. Glazebrook, Prof. W. M. Hicks, Prof. W. Ingram.
1886. Birmingham	Prof. G. H. Darwin, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. J. H. Poynting, W. N. Shaw.
1887. Manchester	Prof. Sir R. S. Ball, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. H. Lamb, W. N. Shaw.
1888. Bath.....	Prof. G. F. Fitzgerald, M.A., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw.
1889. Newcastle-upon-Tyne	Capt. W. de W. Abney, C.B., R.E., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw, H. Stroud.
1890. Leeds	J. W. L. Glaisher, Sc.D., F.R.S., V.P.R.A.S.	R. T. Glazebrook, Prof. A. Lodge, W. N. Shaw, Prof. W. Stroud.
1891. Cardiff.....	Prof. O. J. Lodge, D.Sc., LL.D., F.R.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Prof. A. L. Selby.
1892. Edinburgh	Prof. A. Schuster, Ph.D., F.R.S., F.R.A.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1893. Nottingham	R. T. Glazebrook, M.A., F.R.S.	W. T. A. Emtage, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1894. Oxford.....	Prof. A. W. Rücker, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, J. Walker.
1895. Ipswich ...	Prof. W. M. Hicks, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, G. T. Walker, W. Watson.
1896. Liverpool...	Prof. J. J. Thomson, M.A., D.Sc., F.R.S.	Prof. W. H. Heaton, J. L. Howard, Prof. A. Lodge, G. T. Walker, W. Watson.
1897. Toronto ...	Prof. A. R. Forsyth, M.A., F.R.S.	Prof. W. H. Heaton, J. C. Glashan, J. L. Howard, Prof. J. C. McLennan.
1898. Bristol.....	Prof. W. E. Ayrton, F.R.S....	A. P. Chattock, J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1899. Dover	Prof. J. H. Poynting, F.R.S.	J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1900. Bradford ...	Dr. J. Larmor, F.R.S.—*Dep. of Astronomy*, Dr. A. A. Common, F.R.S.	P. H. Cowell, A. Fowler, C. H. Lees, C. J. L. Wagstaffe, W. Watson, E. T. Whittaker.
1901. Glasgow ...	Major P. A. MacMahon, F.R.S.—*Dep. of Astronomy*, Prof. H. H. Turner, F.R.S.	H. S. Carslaw, C. H. Lees, W. Stewart, Prof. L. R. Wilberforce.
1902. Belfast.....	Prof. J. Purser, LL.D., M.R.I.A.—*Dep. of Astronomy*, Prof. A. Schuster, F.R.S.	H. S. Carslaw, A. R. Hinks, A. Larmor, C. H. Lees, Prof. W. B. Morton, A. W. Porter.
1903. Southport	C. Vernon Boys, F.R.S.—*Dep. of Astronomy and Meteorology*, Dr. W. N. Shaw, F.R.S.	D. E. Benson, A. R. Hinks, R. W. H. T. Hudson, Dr. C. H. Lees, J. Loton, A. W. Porter.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford.....	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope.....	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin.....	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol.....	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.....	Prof. Johnston, Prof. Miller, Dr. Reynolds.

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Date and Place	Presidents	Secretaries
1838 Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, R. Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.....	Prof. Apjohn, M.R.I.A.....	R. Hunt, Dr. Sweeny.
1844. York.....	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton.	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford.....	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.....	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E. ...	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast.....	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin.....	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford.....	Prof. B. C. Brodie, F.R.S.....	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. H. Miller, M.A., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.....	W. Odling, M.B., F.R.S.....	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. Y. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.

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Date and Place	Presidents	Secretaries
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast.....	Prof. A. Crum Brown, M.D., F.R.S.E.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S..... ..	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S. ...	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. P. Bedson, H. B. Dixon, W. R. E. Hodgkinson, J. M. Thomson.
1881. York.....	Prof. A. W. Williamson, F.R.S.	P. P. Bedson, H. B. Dixon, T. Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E. Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	P. P. Bedson, H. B. Dixon, H. F. Morley, W. W. J. Nicol, C. J. Woodward.
1887. Manchester	Dr. E. Schunck, F.R.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.....	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, H. Forster Morley, R. E. Moyle, W. W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S.	H. Forster Morley, D. H. Nagel, W. W. J. Nicol, H. L. Pattinson, jun.
1890. Leeds	Prof. T. E. Thorpe, B.Sc., Ph.D., F.R.S., Treas. C.S.	C. H. Bothamley, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1891. Cardiff.....	Prof. W. C. Roberts-Austen, C.B., F.R.S.	C. H. Bothamley, H. Forster Morley, W. W. J. Nicol, G. S. Turpin.
1892. Edinburgh	Prof. H. McLeod, F.R.S.....	J. Gibson, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1893. Nottingham	Prof. J. Emerson Reynolds, M.D., D.Sc., F.R.S.	J. B. Coleman, M. J. R. Dunstan, D. H. Nagel, W. W. J. Nicol.
1894. Oxford.....	Prof. H. B. Dixon, M.A., F.R.S.	A. Colefax, W. W. Fisher, Arthur Harden, H. Forster Morley.

SECTION B (*continued*).—CHEMISTRY.

1895. Ipswich ...	Prof. R. Meldola, F.R.S.	E. H. Fison, Arthur Harden, C. A. Kohn, J. W. Rodger.
1896. Liverpool...	Dr. Ludwig Mond, F.R.S.	Arthur Harden, C. A. Kohn.
1897. Toronto ...	Prof. W. Ramsay, F.R.S.....	Prof. W. H. Ellis, A. Harden, C. A. Kohn, Prof. R. F. Ruttan.
1898. Bristol.....	Prof. F. R. Japp, F.R.S.	C. A. Kohn, F. W. Stoddart, T. K. Rose.
1899. Dover	Horace T. Brown, F.R.S.....	A. D. Hall, C. A. Kohn, T. K. Rose, Prof. W. P. Wynne.
1900. Bradford ...	Prof. W. H. Perkin, F.R.S. ...	W. M. Gardner, F. S. Kipping, W. J. Pope, T. K. Rose.
1901. Glasgow ...	Prof. Percy F. Frankland, F.R.S.	W. C. Anderson, G. G. Henderson, W. J. Pope, T. K. Rose.

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Date and Place	Presidents	Secretaries
1902. Belfast.....	Prof. E. Divers, F.R.S.....	R. F. Blake, M. O. Forster, Prof. G. G. Henderson, Prof. W. J. Pope.
1903. Southport	Prof. W. N. Hartley, D.Sc., F.R.S.	Dr. M. O. Forster, Prof. G. G. Henderson, J. Ohm, Prof. W. J. Pope.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford.....	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	J. Phillips, T. J. Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin.....	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol.....	Rev. Dr. Buckland, F.R.S.—*Geog.*, R.I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geog.*, G.B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Capt. H. M. Denham, R.N.
1838. Newcastle..	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geog.*, G.B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, H. Murray, H. E. Strickland, J. Scoular.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork.....	Richard E. Griffith, F.R.S. ...	F. M. Jennings, H. E. Strickland.
1844. York.....	Henry Warburton, Pres. G. S.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A. F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham, Dr. C. T. Beke.
1847. Oxford.....	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, F.R.S.	S. Benson, Prof. Oldham, Prof. Ramsay
1849. Birmingham	Sir Charles Lyell, F.R.S.....	J. B. Jukes, Prof. Oldham, A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

SECTION C (*continued*).—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast.....	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull.....	Prof. Sedgwick, F.R.S.....	Prof. Harkness, William Lawton.
1854. Liverpool..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	J. Bryce, Prof. Harkness, Prof. Nicol.

[1] Geography was constituted a separate Section, see page lxv.

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Date and Place	Presidents	Secretaries
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, G. Sanders, R. H. Scott.
1858. Leeds	William Hopkins, M.A., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, F.R.S...	Prof. Harkness, E. Hull, J. W. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath.....	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B., F.R.S.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S.....	E. Hull, W. Pengelly, H. Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford ...	Prof. J. Phillips, F.R.S.	L.C.Miall, R.H.Tiddeman, W.Topley.
1874. Belfast.....	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol.....	Dr. T. Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow ...	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth...	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin.....	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield ...	Prof. P. M. Duncan, F.R.S.	W. Topley, G. Blake Walker.
1880. Swansea ...	H. C. Sorby, F.R.S., F.G.S....	W. Topley, W. Whitaker.
1881. York.....	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal ...	W. T. Blanford, F.R.S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen ...	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.

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Date and Place	Presidents	Secretaries
1888. Bath.....	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.
1890. Leeds	Prof. A. H. Green, M.A., F.R.S., F.G.S.	J. E. Bedford, Dr. F. H. Hatch, J. E. Marr, W. W. Watts.
1891. Cardiff.....	Prof. T. Rupert Jones, F.R.S., F.G.S.	W. Galloway, J. E. Marr, Clement Reid, W. W. Watts.
1892. Edinburgh	Prof. C. Lapworth, LL.D., F.R.S., F.G.S.	H. M. Cadell, J. E. Marr, Clement Reid, W. W. Watts.
1893. Nottingham	J. J. H. Teall, M.A., F.R.S., F.G.S.	J. W. Carr, J. E. Marr, Clement Reid, W. W. Watts.
1894. Oxford.....	L. Fletcher, M.A., F.R.S. ...	F. A. Bather, A. Harker, Clement Reid, W. W. Watts.
1895. Ipswich ...	W. Whitaker, B.A., F.R.S. ...	F. A. Bather, G. W. Lamplugh, H. A. Miers, Clement Reid.
1896. Liverpool...	J. E. Marr, M.A., F.R.S.....	J. Lomas, Prof. H. A. Miers, C. Reid.
1897. Toronto ...	Dr. G. M. Dawson, C.M.G., F.R.S.	Prof. A. P. Coleman, G. W. Lamplugh, Prof. H. A. Miers.
1898. Bristol.....	W. H. Hudleston, F.R.S.....	G. W. Lamplugh, Prof. H. A. Miers, H. Pentecost.
1899. Dover	Sir Archibald Geikie, F.R.S.	J. W. Gregory, G. W. Lamplugh, Capt. McDakin, Prof. H. A. Miers.
1900. Bradford ...	Prof. W. J. Sollas, F.R.S. ...	H. L. Bowman, Rev. W. L. Carter, G. W. Lamplugh, H. W. Monckton.
1901. Glasgow ...	John Horne, F.R.S.	H. L. Bowman, H. W. Monckton.
1902. Belfast.....	Lieut.-Gen. C. A. McMahon, F.R.S.	H. L. Bowman, H. W. Monckton, J. St. J. Phillips, H. J. Seymour.
1903. Southport	Prof. W. W. Watts, M.A., M.Sc.	H. L. Bowman, Rev. W. L. Carter, J. Lomas, H. W. Monckton.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford.....	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh.	Prof. Graham.....	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin.....	Dr. Allman.....	J. Curtis, Dr. Litton.
1836. Bristol.....	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay.....	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.....	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.....	William Thompson, F.L.S....	G. J. Allman, Dr. Lankester, R. Patterson.

[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. lxiv.

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Date and Place	Presidents	Secretaries
1844. York.....	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford.....	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lxiv.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.....	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S. L. & E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast.....	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin.....	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford.....	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath.....	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham[1]	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.

1866. Nottingham	Prof. Huxley, F.R.S.—*Dep. of Physiol.*, Prof. Humphry, F.R.S.—*Dep. of Anthropol.*, A. R. Wallace.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.

[1] The title of Section D was changed to Biology.

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Date and Place	Presidents	Secretaries
1869. Exeter	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.— *Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh.	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.— *Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast.....	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, F.R.S.—*Dep. of Anth.*, Prof. Rolleston, F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.L.S.— *Dep. of Zool. and Bot.*, Prof. A. Newton, F.R.S.— *Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, F.R.S.— *Dep. of Anat. and Physiol.*, Prof. Macalister.—*Dep. of Anthropol.*, F. Galton, F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.— *Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S. —*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, F.R.S.—*Dep. of Anat. & Physiol.*, F. M. Balfour, F.R.S.—*Dep. of Anthropol.*, F. W. Rudler.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York.....	R. Owen, F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M'Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.

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Date and Place	Presidents	Secretaries
1882. Southampton.	Prof. A. Gamgee, M.D., F.R.S. —*Dep. of Zool. and Bot.*, Prof. M. A. Lawson, F.L.S. —*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport[1]	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.
1884. Montreal ...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen ...	Prof. W. C. M'Intosh, M.D., LL.D., F.R.S., F.R.S.E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.
1887. Manchester	Prof. A. Newton, M.A., F.R.S., F.L.S., V.P.Z.S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath	W. T. Thiselton-Dyer, C.M.G., F.R.S., F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner, Prof. W. D. Halliburton.
1889. Newcastle-upon-Tyne	Prof. J. S. Burdon Sanderson, M.A., M.D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.
1890. Leeds	Prof. A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S.	S. F. Harmer, Prof. W. A. Herdman, S. J. Hickson, F. W. Oliver, H. Wager, H. Marshall Ward.
1891. Cardiff	Francis Darwin, M.A., M.B., F.R.S., F.L.S.	F. E. Beddard, Prof. W. A. Herdman, Dr. S. J. Hickson, G. Murray, Prof. W. N. Parker, H. Wager.
1892. Edinburgh	Prof. W. Rutherford, M.D., F.R.S., F.R.S.E.	G. Brook, Prof. W. A. Herdman, G. Murray, W. Stirling, H. Wager.
1893. Nottingham[2]	Rev. Canon H. B. Tristram, M.A., LL.D., F.R.S.	G. C. Bourne, J. B. Farmer, Prof. W. A. Herdman, S. J. Hickson, W. B. Ransom, W. L. Sclater.
1894. Oxford[3] ...	Prof. I. Bayley Balfour, M.A., F.R.S.	W. W. Benham, Prof. J. B. Farmer, Prof. W. A. Herdman, Prof. S. J. Hickson, G. Murray, W. L. Sclater.

SECTION D (*continued*).—ZOOLOGY.

1895. Ipswich ...	Prof. W. A. Herdman, F.R.S.	G. C. Bourne, H. Brown, W. E. Hoyle, W. L. Sclater.
1896. Liverpool...	Prof. E. B. Poulton, F.R.S. ...	H. O. Forbes, W. Garstang, W. E. Hoyle.
1897. Toronto ...	Prof. L. C. Miall, F.R.S.	W. Garstang, W. E. Hoyle, Prof. E. E. Prince.
1898. Bristol	Prof. W. F. R. Weldon, F.R.S.	Prof. R. Boyce, W. Garstang, Dr. A. J. Harrison, W. E. Hoyle.
1899. Dover	Adam Sedgwick, F.R.S.	W. Garstang, J. Graham Kerr.
1900. Bradford ...	Dr. R. H. Traquair, F.R.S. ...	W. Garstang, J. G. Kerr, T. H. Taylor, Swale Vincent.
1901. Glasgow ...	Prof. J. Cossar Ewart, F.R.S.	J. G. Kerr, J. Rankin, J. Y. Simpson.

[1] Anthropology was made a separate Section, see p. lxxi.
[2] Physiology was made a separate Section, see p. lxxii.
[3] The title of Section D was changed to Zoology

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Date and Place	Presidents	Secretaries
1902. Belfast.....	Prof. G. B. Howes, F.R.S. ...	Prof. J. G. Kerr, R. Patterson, J. Y. Simpson.
1903. Southport	Prof. S. J. Hickson, F.R.S. ...	Dr. J. H. Ashworth, J. Barcroft, A. Quayle, Dr. J. Y. Simpson, Dr. H. W. M. Tims.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. J. Haviland.....	Dr. H. J. H. Bond, Mr. G. E. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. J. C. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. P. M. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S....	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

SECTION E.—PHYSIOLOGY.

1841. Plymouth...	P. M. Roget, M.D., Sec. R.S.	J. Butter, J. Fuge, R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1] ...	Prof. Ogle, M.D., F.R.S.	T. K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin.....	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir B. Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford.....	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.	Dr. W. Roberts, Dr. Edward Smith
1862. Cambridge	G. E. Paget, M.D.....	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.....	Dr. Edward Smith, F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

[1] Sections D and E were incorporated under the name of 'Section D—Zoology and Botany, including Physiology' (see p. lxi). Section E, being then vacant, was assigned in 1851 to Geography.

[2] *Vide* note on page lxi.

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Date and Place	Presidents	Secretaries

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. lviii.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846. Southampton	Dr. J. C. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	.....	G. Grant Francis.
1849. Birmingham	.....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast.....	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull.....	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin.....	Rev. Dr. J. Henthorn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, F. Galton, P. O'Callaghan, Dr. Norton Shaw, T. Wright.
1859. Aberdeen...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford.....	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S.....	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S.....	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath.....	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee ...	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham J. H. Thomas.
1870. Liverpool...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.

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Date and Place	Presidents	Secretaries
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas.
1872. Brighton ...	Francis Galton, F.R.S.....	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast.....	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol.....	Lieut. - General Strachey, R.E., C.S.I., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.....	H. W. Bates, E. C. Rye, R. O. Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin.....	Prof. Sir C. Wyville Thomson, LL.D., F.R.S., F.R.S.E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea ...	Lieut.-Gen. Sir J. H. Lefroy, C.B., K.C.M.G., R.A., F.R.S.	H. W. Bates, E. C. Rye.
1881. York.....	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye.
1883. Southport	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.
1884. Montreal ...	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R.G.S.	Rev. Abbé Laflamme, J. S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen...	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham	Maj.-Gen. Sir F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie, E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1888. Bath.....	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M.G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.
1890. Leeds	Lieut.-Col. Sir R. Lambert Playfair, K.C.M.G., F.R.G.S.	A. Barker, John Coles, J. S. Keltie, A. Silva White.
1891. Cardiff.....	E. G. Ravenstein, F.R.G.S., F.S.S.	John Coles, J. S. Keltie, H. J. Mackinder, A. Silva White, Dr. Yeats.
1892. Edinburgh	Prof. J. Geikie, D.C.L., F.R.S., V.P.R.Scot.G.S.	J. G. Bartholomew, John Coles, J. S. Keltie, A. Silva White.
1893. Nottingham	H. Seebohm, Sec. R.S., F.L.S., F.Z.S.	Col. F. Bailey, John Coles, H. O. Forbes, Dr. H. R. Mill.
1894. Oxford.....	Capt. W. J. L. Wharton, R.N., F.R.S.	John Coles, W. S. Dalgleish, H. N. Dickson, Dr. H. R. Mill.
1895. Ipswich ...	H. J. Mackinder, M.A., F.R.G.S.	John Coles, H. N. Dickson, Dr. H. R. Mill, W. A. Taylor.
1896. Liverpool...	Major L. Darwin, Sec. R.G.S.	Col. F. Bailey, H. N. Dickson, Dr. H. R. Mill, E. C. DuB. Phillips.
1897. Toronto ...	J. Scott Keltie, LL.D.	Col. F. Bailey, Capt. Deville, Dr. H. R. Mill, J. B. Tyrrell.
1898. Bristol.....	Col. G. Earl Church, F.R.G.S.	H. N. Dickson, Dr. H. R. Mill, H. C. Trapnell.
1899. Dover	Sir John Murray, F.R.S.	H. N. Dickson, Dr. H. O. Forbes, Dr. H. R. Mill.
1900. Bradford ...	Sir George S. Robertson, K.C.S.I.	H. N. Dickson, E. Heawood, E. R. Wethey.
1901. Glasgow ...	Dr. H. R. Mill, F.R.G.S.	H. N. Dickson, E. Heawood, G. Sandeman, A. C. Turner.

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Date and Place	Presidents	Secretaries
1902. Belfast ...	Sir T. H. Holdich, K.C.B. ...	G. G. Chisholm, E. Heawood, Dr. A. J. Herbertson, Dr. J. A. Lindsay.
1903. Southport	Capt. E. W. Creak, R.N., C.B., F.R.S.	E. Heawood, Dr. A. J. Herberstson. E. A. Reeves, Capt. J. C. Underwood.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.....	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.....	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S. ...	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P. ...	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York.....	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford.....	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S. ...	J. Fletcher, Capt. R. Shortrede.
1849 Birmingham	Rt. Hon. Lord Lyttelton.....	Dr. Finch, Prof. Hancock, F. P. G. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast.....	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull.....	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin.....	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.

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Date and Place	Presidents	Secretaries
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford.....	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath.....	W. Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers.....	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant-Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P.	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast.....	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres. S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D.	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York.....	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal ...	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen...	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.
1886. Birmingham	J. B. Martin, M.A., F.S.S.	F. F. Barham, Rev. W. Cunningham, Prof. H. S. Foxwell, J. F. Moss.
1887. Manchester	Robert Giffen, LL.D., V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, J. E. C. Munro, G. H. Sargant.
1888. Bath.....	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.
1890. Leeds	Prof. A. Marshall, M.A., F.S.S.	W. A. Brigg, Rev. Dr. Cunningham, T. H. Elliott, Prof. J. E. C. Munro, L. L. F. R. Price.
1891. Cardiff	Prof. W. Cunningham, D.D., D.Sc., F.S.S.	Prof. J. Brough, E. Cannan, Prof. E. C. K. Gonner, H. Ll. Smith, Prof. W. R. Sorley.

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Date and Place	Presidents	Secretaries
1892. Edinburgh	Hon. Sir C. W. Fremantle, K.C.B.	Prof. J. Brough, J. B. Findlay, Prof. E. C. K. Gonner, H. Higgs, L. L. F. R. Price.
1893. Nottingham	Prof. J. S. Nicholson, D.Sc., F.S.S.	Prof. E. C. K. Gonner, H. de B. Gibbins, J. A. H. Green, H. Higgs, L. L. F. R. Price.
1894. Oxford.....	Prof. C. F. Bastable, M.A., F.S.S.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1895. Ipswich ...	L. L. Price, M.A.	E. Cannan, Prof. E. C. K. Gonner, H. Higgs.
1896. Liverpool...	Rt. Hon. L. Courtney, M.P....	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1897. Toronto ...	Prof. E. C. K. Gonner, M.A.	E. Cannan, H. Higgs, Prof. A. Shortt.
1898. Bristol.....	J. Bonar, M.A., LL.D.	E. Cannan, Prof. A. W. Flux, H. Higgs, W. E. Tanner.
1899. Dover	H. Higgs, LL.B.	A. L. Bowley, E. Cannan, Prof. A. W. Flux, Rev. G. Sarson.
1900. Bradford ...	Major P. G. Craigie, V.P.S.S.	A. L. Bowley, E. Cannan, S. J. Chapman, F. Hooper.
1901. Glasgow ...	Sir R. Giffen, K.C.B., F.R.S.	W. W. Blackie, A. L. Bowley, E. Cannan, S. J. Chapman.
1902. Belfast ...	E. Cannan, M.A., LL.D. ...	A. L. Bowley, Prof. S. J. Chapman, Dr. A. Duffin.
1903. Southport	E. W. Brabrook, C.B.	A. L. Bowley, Prof. S. J. Chapman, Dr. B. W. Ginsburg, G. Lloyd.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol.....	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.....	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A....	James Thomson, Robert Mallet.
1844. York.....	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S.....	Rev. W. T. Kingsley.
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford.....	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich ...	William Cubitt, F.R.S.....	John Head, Charles Manby.
1852. Belfast.....	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, F.R.S.	J. Oldham, J. Thomson, W. S. Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	J. Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. M. Rankine, F.R.S. ...	L. Hill, W. Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, H. M. Jeffery.
1857. Dublin.....	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.

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Date and Place	Presidents	Secretaries
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge.	William Fairbairn, F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle .	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P. Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee.....	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S.....	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, A. Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	C. Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea ...	J. Abernethy, F.R.S.E.....	A. T. Atchison, H. T. Wood.
1881. York.....	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton.	John Fowler, C.E., F.G.S. ...	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport .	J. Brunlees, Pres. Inst. C.E.	A. T. Atchison, E. Rigg, H. T. Wood.
1884. Montreal ...	Sir F. J. Bramwell, F.R.S., V.P. Inst. C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.
1885. Aberdeen...	B. Baker, M. Inst. C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886. Birmingham	Sir J. N. Douglass, M. Inst. C.E	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
1887. Manchester	Prof. Osborne Reynolds, M.A., LL.D., F.R.S.	C. F. Budenberg, W. B. Marshall, E. Rigg.
1888. Bath.....	W. H. Preece, F.R.S., M. Inst. C.E.	C. W. Cooke, W. B. Marshall, E. Rigg, P. K. Stothert.
1889. Newcastle-upon-Tyne	W. Anderson, M. Inst. C.E. ...	C. W. Cooke, W. B. Marshall, Hon. C. A. Parsons, E. Rigg.
1890. Leeds	Capt. A. Noble, C.B., F.R.S., F.R.A.S.	E. K. Clark, C. W. Cooke, W. B. Marshall, E. Rigg.
1891. Cardiff.....	T. Forster Brown, M. Inst. C.E.	C. W. Cooke, Prof. A. C. Elliott, W. B. Marshall, E. Rigg.
1892. Edinburgh	Prof. W. C. Unwin, F.R.S., M. Inst. C.E.	C. W. Cooke, W. B. Marshall, W. C. Popplewell, E. Rigg.

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1893. Nottingham	Jeremiah Head, M.Inst.C.E., F.C.S.	C. W. Cooke, W. B. Marshall, E. Rigg, H. Talbot.
1894. Oxford.....	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, Rev. F. J. Smith.
1895. Ipswich ...	Prof. L. F. Vernon-Harcourt, M.A., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, P. G. M. Stoney.
1896. Liverpool...	Sir Douglas Fox, V.P.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, S. Dunkerley, W. B. Marshall.
1897. Toronto ...	G. F. Deacon, M.Inst.C.E.	Prof. T. Hudson Beare, Prof. Callendar, W. A. Price.
1898. Bristol.....	Sir J. Wolfe-Barry, K.C.B., F.R.S.	Prof. T. H. Beare, Prof. J. Munro, H. W. Pearson, W. A. Price.
1899. Dover	Sir W. White, K.C.B., F.R.S.	Prof. T. H. Beare, W. A. Price, H. E. Stilgoe.
1900. Bradford ...	Sir Alex. R. Binnie, M.Inst. C.E.	Prof. T. H. Beare, C. F. Charnock, Prof. S. Dunkerley, W. A. Price.
1901. Glasgow ...	R. E. Crompton, M.Inst.C.E.	H. Bamford, W.E. Dalby, W. A. Price.
1902. Belfast ...	Prof. J. Perry, F.R.S.	M. Barr, W. A. Price, J. Wylie.
1903. Southport	C. Hawksley, M.Inst.C.E. ...	Prof. W. E. Dalby, W. T. Maccall, W. A. Price.

SECTION H.—ANTHROPOLOGY.

1884. Montreal ...	E. B. Tylor, D.C.L., F.R.S. ...	G. W. Bloxam, W. Hurst.
1885. Aberdeen...	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W Hurst, Dr. A. Macgregor.
1886. Birmingham	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby.
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson.
1888. Bath.....	Lieut.-General Pitt-Rivers, D.C.L., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.
1890. Leeds	Dr. J. Evans, Treas. R.S., F.S.A., F.L.S., F.G.S.	G. W. Bloxam, Dr. C. M. Chadwick, Dr. J. G. Garson.
1891. Cardiff.....	Prof. F. Max Müller, M.A. ...	G. W. Bloxam, Prof. R. Howden, H. Ling Roth, E. Seward.
1892. Edinburgh	Prof. A. Macalister, M.A., M.D., F.R.S.	G. W. Bloxam, Dr. D. Hepburn, Prof. R. Howden, H. Ling Roth.
1893. Nottingham	Dr. R. Munro, M.A., F.R.S.E.	G. W. Bloxam, Rev. T. W. Davies, Prof. R. Howden, F. B. Jevons, J. L. Myres.
1894. Oxford.....	Sir W. H. Flower, K.C.B., F.R.S.	H. Balfour, Dr. J. G. Garson, H. Ling Roth.
1895. Ipswich ...	Prof. W. M. Flinders Petrie, D.C.L.	J. L. Myres, Rev. J. J. Raven, H. Ling Roth.
1896. Liverpool...	Arthur J. Evans, F.S.A.	Prof. A. C. Haddon, J. L. Myres, Prof. A. M. Paterson.
1897. Toronto ...	Sir W. Turner, F.R.S.	A. F. Chamberlain, H. O. Forbes, Prof. A. C. Haddon, J. L. Myres.
1898. Bristol.....	E. W. Brabrook, C.B.	H. Balfour, J. L. Myres, G. Parker.
1899. Dover	C. H. Read, F.S.A.	H. Balfour, W. H. East, Prof. A. C. Haddon, J. L. Myres.
1900. Bradford ...	Prof. John Rhys, M.A.....	Rev. E. Armitage, H. Balfour, W. Crooke, J. L. Myres.
1901. Glasgow ...	Prof. D. J. Cunningham, F.R.S.	W. Crooke, Prof. A. F. Dixon, J. F. Gemmill, J. L. Myres.
1902. Belfast ...	Dr. A. C. Haddon, F.R.S. ...	R. Campbell, Prof. A. F. Dixon, J. L. Myres.
1903. Southport	Prof. J. Symington, F.R.S. ...	E. N. Fallaize, H. S. Kingsford, E. M. Littler, J. L. Myres.

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Date and Place	Presidents	Secretaries
SECTION I.—PHYSIOLOGY (including EXPERIMENTAL PATHOLOGY AND EXPERIMENTAL PSYCHOLOGY).		
1894. Oxford.....	Prof. E. A. Schäfer, F.R.S., M.R.C.S.	Prof. F. Gotch, Dr. J. S. Haldane, M. S. Pembrey.
1896. Liverpool...	Dr. W. H. Gaskell, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington.
1897. Toronto ...	Prof. Michael Foster, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington, Dr. L. E. Shore.
1899. Dover	J. N. Langley, F.R.S.	Dr. Howden, Dr. L. E. Shore, Dr. E. H. Starling.
1901. Glasgow ...	Prof. J. G. McKendrick.	W. B. Brodie, W. A. Osborne, Prof. W. H. Thompson.
1902. Belfast ...	Prof. W. D. Halliburton, F.R.S.	J. Barcroft, Dr. W. A. Osborne, Dr. C. Shaw.
SECTION K.—BOTANY.		
1895. Ipswich ...	W. T. Thiselton-Dyer, F.R.S.	A. C. Seward, Prof. F. E. Weiss.
1896. Liverpool...	Dr. D. H. Scott, F.R.S.	Prof. Harvey Gibson, A. C. Seward, Prof. F. E. Weiss.
1897. Toronto ...	Prof. Marshall Ward, F.R.S.	Prof. J. B. Farmer, E. C. Jeffrey, A. C. Seward, Prof. F. E. Weiss.
1898. Bristol	Prof. F. O. Bower, F.R.S. ...	A. C. Seward, H. Wager, J. W. White.
1899. Dover	Sir George King, F.R.S.	G. Dowker, A. C. Seward, H. Wager,
1900. Bradford ...	Prof. S. H. Vines, F.R.S.	A. C. Seward, H. Wager, W. West.
1901. Glasgow ...	Prof. I. B. Balfour, F.R.S. ...	D. T. Gwynne-Vaughan, G. F. Scott-Elliot, A. C. Seward, H. Wager.
1902. Belfast ...	Prof. J. R. Green, F.R.S.	A. G. Tansley, Rev. C. H. Waddell, H. Wager, R. H. Yapp.
1903. Southport	A. C. Seward, F.R.S.	H. Ball, A. G. Tansley, H. Wager, R. H. Yapp.
SECTION L.—EDUCATIONAL SCIENCE.		
1901. Glasgow ...	Sir John E. Gorst, F.R.S. ...	R. A. Gregory, W. M. Heller, R. Y. Howie, C. W. Kimmins, Prof. H. L. Withers.
1902. Belfast ...	Prof. H. E. Armstrong, F.R.S.	Prof. R. A. Gregory, W. M. Heller, R. M. Jones, Dr. C. W. Kimmins, Prof. H. L. Withers.
1903. Southport	Sir W. de W. Abney, K.C.B., F.R.S.	Prof. R. A. Gregory, W. M. Heller, Dr. C. W. Kimmins, Dr. H. L. Snape.

LIST OF EVENING DISCOURSES.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S.....	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison.....	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.....	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S.....	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson.....	The Earl of Rosse's Telescope.

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Date and Place	Lecturer	Subject of Discourse
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.....	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy,F.R.S.,Astron.Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive Substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford.....	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.....	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S....	The Dodo (*Didus ineptus*).
1848. Swansea ...	John Percy, M.D., F.R.S.....	Metallurgical Operations of Swansea and its Neighbourhood.
	W. Carpenter, M.D., F.R.S....	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying Velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich ...	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G.B.Airy,F.R.S.,Astron. Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast.....	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent Discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent Discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.....	The present state of Photography.
1854. Liverpool...	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of Researches in Terrestrial Magnetism.
1855. Glasgow ...	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson ...	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform Research up to the present time.
	W. R. Grove, F.R.S.....	Correlation of Physical Forces.
1857. Dublin.....	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford.....	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.

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Date and Place	Lecturer	Subject of Discourse
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal.	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.	The Balloon Ascents made for the British Association.
1864. Bath	Prof. Roscoe, F.R.S.	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S.	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S.	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.	Insular Floras.
1867. Dundee	Archibald Geikie, F.R.S.	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of Knowledge regarding Meteors and Meteorites.
1868. Norwich	J. Fergusson, F.R.S.	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S.	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.	Some Recent Investigations and Applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilisation.
1872. Brighton	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarised Light.
	F. J. Bramwell, F.R.S.	Railway Safety Appliances.
1876. Glasgow	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The 'Challenger' Expedition.
1877. Plymouth	W. Warington Smyth, M.A., F.R.S.	Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.	The New Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.

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Date and Place	Lecturer	Subject of Discourse
1880. Swansea ...	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S.	Mental Imagery.
1881. York	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S.	The Electric Discharge, its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick.	Galvanic and Animal Electricity.
1884. Montreal ...	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen...	Prof. W. G. Adams, F.R.S.	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E.	The Great Ocean Basins.
1886. Birmingham	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D.	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S.	The Rate of Explosions in Gases.
	Col. Sir F. de Winton	Explorations in Central Africa.
1888. Bath	Prof. W. E. Ayrton, F.R.S.	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.	How Plants maintain themselves in the Struggle for Existence.
1890. Leeds	E. B. Poulton, M.A., F.R.S.	Mimicry.
	Prof. C. Vernon Boys, F.R.S.	Quartz Fibres and their Applications.
1891. Cardiff	Prof. L. C. Miall, F.L.S., F.G.S.	Some Difficulties in the Life of Aquatic Insects.
	Prof. A. W. Rücker, M.A., F.R.S.	Electrical Stress.
1892. Edinburgh	Prof. A. M. Marshall, F.R.S.	Pedigrees.
	Prof. J. A. Ewing, M.A., F.R.S.	Magnetic Induction.
1893. Nottingham	Prof. A. Smithells, B.Sc.	Flame.
	Prof. Victor Horsley, F.R.S.	The Discovery of the Physiology of the Nervous System.
1894. Oxford	J. W. Gregory, D.Sc., F.G.S.	Experiences and Prospects of African Exploration.
	Prof. J. Shield Nicholson, M.A.	Historical Progress and Ideal Socialism.
1895. Ipswich ...	Prof. S. P. Thompson, F.R.S.	Magnetism in Rotation.
	Prof. Percy F. Frankland, F.R.S.	The Work of Pasteur and its various Developments.
1896. Liverpool...	Dr. F. Elgar, F.R.S.	Safety in Ships.
	Prof. Flinders Petrie, D.C.L.	Man before Writing.
1897. Toronto ...	Prof. W. C. Roberts-Austen, F.R.S.	Canada's Metals.
	J. Milne, F.R.S.	Earthquakes and Volcanoes.
1898. Bristol	Prof. W. J. Sollas, F.R.S.	Funafuti: the Study of a Coral Island.
	Herbert Jackson	Phosphorescence.
1899. Dover	Prof. Charles Richet.	La vibration nerveuse.
	Prof. J. Fleming, F.R.S.	The Centenary of the Electric Current.
1900. Bradford ...	Prof. F. Gotch, F.R.S.	Animal Electricity.
	Prof. W. Stroud.	Range Finders.
1901. Glasgow ...	Prof. W. Ramsay, F.R.S.	The Inert Constituents of the Atmosphere.
	F. Darwin, F.R.S.	The Movements of Plants.

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Date and Place	Lecturer	Subject of Discourse
1902. Belfast ...	Prof. J. J. Thomson, F.R.S....	Becquerel Rays and Radio-activity.
	Prof. W. F. R. Weldon, F.R.S.	Inheritance.
1903. Southport	Dr. R. Munro	Man as Artist and Sportsman in the Palæolithic Period.
	Dr. A. Rowe	The Old Chalk Sea, and some of its Teachings.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturer	Subject of Discourse
1867. Dundee.....	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	The modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool...	Sir John Lubbock, Bart., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.....	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B....	A Journey through Africa.
1877. Plymouth...	W. H. Preece.....	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	John Evans, D.C.L., Treas. R.S.	Unwritten History, and how to read it.
1883. Southport	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S.....	Comets.
1885. Aberdeen ...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath.....	Sir John Lubbock, Bart., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.
1890. Leeds	Prof. J. Perry, D.Sc., F.R.S.	Spinning Tops.
1891. Cardiff.....	Prof. S. P. Thompson, F.R.S.	Electricity in Mining.
1892. Edinburgh	Prof. C. Vernon Boys, F.R.S.	Electric Spark Photographs.
1893. Nottingham	Prof. Vivian B. Lewes.....	Spontaneous Combustion.
1894. Oxford.....	Prof. W. J. Sollas, F.R.S. ...	Geologies and Deluges.
1895. Ipswich ...	Dr. A. H. Fison	Colour.
1896. Liverpool...	Prof. J. A. Fleming, F.R.S....	The Earth a Great Magnet.
1897. Toronto ...	Dr. H. O. Forbes	New Guinea.
1898. Bristol.....	Prof. E. B. Poulton, F.R.S.	The ways in which Animals Warn their enemies and Signal to their friends.
1900. Bradford ...	Prof. S. P. Thompson, F.R.S.	Electricity in the Industries.
1901. Glasgow ...	H. J. Mackinder, M.A.....	The Movements of Men by Land and Sea.
1902. Belfast ...	Prof. L. C. Miall, F.R.S.	Gnats and Mosquitoes.
1903. Southport	Dr. J. S. Flett	Martinique and St. Vincent: the Eruptions of 1902.

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Secretaries.—Prof. W. E. Dalby, M.A.; W. T. Maccall, M.Sc.; W. A. Price, M.A. (*Recorder*).

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Dr. THE GENERAL TREASURER'S ACCOUNT,

1902-1903. RECEIPTS.

	£	s.	d.
Balance brought forward	1565	19	11
Life Compositions (including Transfers)	351	0	0
New Annual Members' Subscriptions	202	0	0
Annual Subscriptions	586	0	0
Sale of Associates' Tickets	635	0	0
Sale of Ladies' Tickets	305	0	0
Sale of Publications	141	0	7
Dividend on Consols	167	12	4
Dividend on India 3 per Cents	101	5	0
Interest on Deposit	37	11	6
Unexpended Balance of Grant returned by Committee on the Zoology and Botany of the West India Islands	25	0	0
	£4117	9	4

Investments.

	£	s.	d.
Consols	6501	10	5
India 3 per Cents	3600	0	0
	£10,101	10	5

G. CAREY FOSTER, *General Treasurer.*

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from July 1, 1902, to June 30, 1903. *Cr.*

1902-1903.	EXPENDITURE.	£	s.	d.
	Expenses of Belfast Meeting (including Printing, Advertising, Payment of Clerks, &c., &c.)	148	11	6
	Rent and Office Expenses	91	1	0
	Salaries, &c.	526	0	9
	Printing, Binding, &c.	1107	1	4
	Contribution to Antarctic Expedition	750	0	0
	Payment of Grants made at Belfast:			
	Electrical Standards	35 0 0		
	Seismological Observations	40 0 0		
	Investigation of the Upper Atmosphere by means of Kites	75 0 0		
	Magnetic Observations at Falmouth	40 0 0		
	Study of Hydroaromatic Substances	20 0 0		
	Erratic Blocks	10 0 0		
	Exploration of Irish Caves	40 0 0		
	Underground Waters of North-west Yorkshire	40 0 0		
	Life-zones in British Carboniferous Rocks	5 0 0		
	Geological Photographs	10 0 0		
	Table at the Zoological Station, Naples	100 0 0		
	Index Generum et Specierum Animalium	100 0 0		
	Tidal Bore, Sea Waves, and Beaches	15 0 0		
	Scottish National Antarctic Expedition	50 0 0		
	Legislation affecting Women's Labour	25 0 0		
	Researches in Crete	100 0 0		
	Age of Stone Circles	8 13 2		
	Anthropometric Investigation	5 0 0		
	Anthropometry of the Todas and other Tribes of Southern India	50 0 0		
	The State of Solution of Proteids	20 0 0		
	Investigation of the Cyanophyceæ	25 0 0		
	Respiration of Plants	12 0 0		
	Conditions of Health essential for School Instruction	5 0 0		
	Corresponding Societies Committee	20 0 0		
		845	13	2
		3468	7	9
	Balance at Bank of England (Western Branch) £ 698 7 3			
	Less Cheque not presented 52 10 0			
	645 17 3			
	Cash in hand 3 4 4			
		649	1	7
		£4117	9	4

I have examined the above Account with the books and vouchers of the Association, and certify the same to be correct. I have also verified the balance at the Bankers', and have ascertained that the Investments are registered in the names of the Trustees.

Approved—
L. L. PRICE.
E. W BRABROOK, } *Auditors.*

W. B. KERN, *Chartered Accountant*,
3 Church Court, Old Jewry, E.C.
July 23, 1903.

1903.

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Table showing the Attendance and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27	York	The Earl Fitzwilliam, D.C.L., F.R.S.	—	—
1832, June 19	Oxford	The Rev. W. Buckland, F.R.S.	—	—
1833, June 25	Cambridge	The Rev. A. Sedgwick, F.R.S.	—	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, D.C.L., F.R.S.	—	—
1835, Aug. 10	Dublin	The Rev. Provost Lloyd, LL.D., F.R.S.	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne, F.R.S.	—	—
1837, Sept. 11	Liverpool	The Earl of Burlington, F.R.S.	—	—
1838, Aug. 10	Newcastle-on-Tyne	The Duke of Northumberland, F.R.S.	—	—
1839, Aug. 26	Birmingham	The Rev. W. Vernon Harcourt, F.R.S.	—	—
1840, Sept. 17	Glasgow	The Marquis of Breadalbane, F.R.S.	—	—
1841, July 20	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23	Manchester	The Lord Francis Egerton, F.G.S.	303	169
1843, Aug. 17	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26	York	The Rev. G. Peacock, D.D., F.R.S.	226	150
1845, June 19	Cambridge	Sir John F. W. Herschel, Bart., F.R.S.	313	36
1846, Sept. 10	Southampton	Sir Roderick I. Murchison, Bart., F.R.S.	241	10
1847, June 23	Oxford	Sir Robert H. Inglis, Bart., F.R.S.	314	18
1848, Aug. 9	Swansea	The Marquis of Northampton, Pres. R.S.	149	3
1849, Sept. 12	Birmingham	The Rev. T. R. Robinson, D.D., F.R.S.	227	12
1850, July 21	Edinburgh	Sir David Brewster, K.H., F.R.S.	235	9
1851, July 2	Ipswich	G. B. Airy, Astronomer Royal, F.R.S.	172	8
1852, Sept. 1	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6	Cheltenham	Prof. C. G. B. Daubeny, M.D., F.R.S.	182	14
1857, Aug. 26	Dublin	The Rev. H. Lloyd, D.D., F.R.S.	236	15
1858, Sept. 22	Leeds	Richard Owen, M.D., D.C.L., F.R.S.	222	42
1859, Sept. 14	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27	Oxford	The Lord Wrottesley, M.A., F.R.S.	286	21
1861, Sept. 4	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1	Cambridge	The Rev. Professor Willis, M.A., F.R.S.	239	15
1863, Aug. 26	Newcastle-on-Tyne	Sir William G. Armstrong, C.B., F.R.S.	203	36
1864, Sept. 13	Bath	Sir Charles Lyell, Bart., M.A., F.R.S.	287	40
1865, Sept. 6	Birmingham	Prof. J. Phillips, M.A., LL.D., F.R.S.	292	44
1866, Aug. 22	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4	Dundee	The Duke of Buccleuch, K.C.B., F.R.S.	167	25
1868, Aug. 19	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18	Exeter	Prof. G. G. Stokes, D.C.L., F.R.S.	204	21
1870, Sept. 14	Liverpool	Prof. T. H. Huxley, LL.D., F.R.S.	314	39
1871, Aug. 2	Edinburgh	Prof. Sir W. Thomson, LL.D., F.R.S.	246	28
1872, Aug. 14	Brighton	Dr. W. B. Carpenter, F.R.S.	245	36
1873, Sept. 17	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25	Bristol	Sir John Hawkshaw, F.R.S.	239	36
1876, Sept. 6	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25	Swansea	A. C. Ramsay, LL.D., F.R.S.	144	11
1881, Aug. 31	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23	Southampton	Dr. C. W. Siemens F.R.S.	178	17
1883, Sept. 19	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, F.R.S.	235	20
1885, Sept. 9	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1	Birmingham	Sir J. W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5	Bath	Sir F. J. Bramwell, F.R.S.	266	36
1889, Sept. 11	Newcastle-on-Tyne	Prof. W. H. Flower, C.B., F.R.S.	277	20
1890, Sept. 3	Leeds	Sir F. A. Abel, C.B., F.R.S.	259	21
1891, Aug. 19	Cardiff	Dr. W. Huggins, F.R.S.	189	24
1892, Aug. 3	Edinburgh	Sir A. Geikie, LL.D., F.R.S.	280	14
1893, Sept. 13	Nottingham	Prof. J. S. Burdon Sanderson, F.R.S.	201	17
1894, Aug. 8	Oxford	The Marquis of Salisbury, K.G., F.R.S.	327	21
1895, Sept. 11	Ipswich	Sir Douglas Galton, K.C.B., F.R.S.	214	13
1896, Sept. 16	Liverpool	Sir Joseph Lister, Bart., Pres. R.S.	330	31
1897, Aug. 18	Toronto	Sir John Evans, K.C.B., F.R.S.	120	8
1898, Sept. 7	Bristol	Sir W. Crookes, F.R.S.	281	19
1899, Sept. 13	Dover	Sir Michael Foster, K.C.B., Sec. R.S.	296	20
1900, Sept. 5	Bradford	Sir William Turner, D.C.L., F.R.S.	267	13
1901, Sept. 11	Glasgow	Prof. A. W. Rücker, D.Sc., Sec. R.S.	310	37
1902, Sept. 10	Belfast	Prof. J. Dewar, LL.D., F.R.S.	243	21
1903, Sept. 9	Southport	Sir Norman Lockyer, K.C.B., F.R.S.	250	21

* Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.

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at Annual Meetings of the Association.

Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total	Amount received during the Meeting	Grants for Scientific Purposes	Year
—	—	—	—	—	353	—	—	1831
—	—	—	—	—	—	—	—	1832
—	—	—	—	—	900	—	—	1833
—	—	—	—	—	1298	—	£20 0 0	1834
—	—	—	—	—	—	—	167 0 0	1835
—	—	—	—	—	1350	—	435 0 0	1836
—	—	—	—	—	1840	—	922 12 6	1837
—	—	—	1100*	—	2400	—	932 2 2	1838
—	—	—	—	34	1438	—	1596 11 0	1839
—	—	—	—	40	1353	—	1846 16 4	1840
46	317	—	60*	—	891	—	1235 10 11	1841
75	376	33†	331*	28	1316	—	1449 17 8	1842
71	185	—	160	—	—	—	1565 10 2	1843
45	190	9†	260	—	—	—	981 12 8	1844
94	22	407	172	35	1079	—	831 9 9	1845
65	39	270	196	36	857	—	685 16 0	1846
197	40	496	203	53	1320	—	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
98	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1804 0 0	766 19 6	1860
184	125	1589	791	15	3138	3844 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1780 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1885 0 0	1873
232	85	817	639	12	1961	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 8 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	962	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1855 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	429	11	2453	2532 0 0	995 0 6	1886
510	244	1985	498	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	12	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	21	2437	2441 0 0	1417 0 11	1889
368	92	680	324	12	1776	1776 0 0	789 16 8	1890
341	152	672	107	35	1497	1664 0 0	1029 10 0	1891
413	141	733	439	50	2070	2007 0 0	864 10 0	1892
328	57	773	268	17	1661	1653 0 0	907 15 6	1893
435	69	941	451	77	2321	2175 0 0	883 15 6	1894
290	31	493	261	22	1324	1236 0 0	977 15 5	1895
383	139	1384	873	41	3181	3228 0 0	1194 5 1	1896
286	125	682	100	41	1362	1398 0 0	1059 10 8	1897
327	96	1051	639	83	2416	2299 0 0	1212 0 0	1898
324	68	548	120	27	1403	1328 0 0	1430 14 2	1899
297	45	801	482	9	1915	1801 0 0	1072 10 0	1900
374	131	794	246	20	1912	2016 0 0	945 0 0	1901
314	86	647	306	6	1620	1644 0 0	947 0 0	1902
319	90	688	365	21	1754	1762 0 0	845 13 2	1903

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.

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OFFICERS AND COUNCIL, 1903-1904.

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SIR NORMAN LOCKYER, K.C.B., LL.D., F.R.S., Correspondant de l'Institut de France.

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CHARLES WELD-BLUNDELL, Esq.

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JOSEPH MARTIN, Esq., Chairman of the Isle of Ely County Council.
P. H. YOUNG, Esq., Deputy Mayor of Cambridge.

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Professor G. CAREY FOSTER, LL.D., D.Sc., F.R.S., Burlington House, London, W.

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ASSISTANT GENERAL SECRETARY.

J. G. GARSON, M.D., Burlington House, London, W.

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A. E. SHIPLEY, Esq., M.A.

LOCAL SECRETARIES FOR THE MEETING AT CAMBRIDGE.

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A. C. SEWARD, Esq., M.A., F.R.S.
S. SKINNER, Esq., M.A.
J. E. L. WHITEHEAD, Esq., M.A.

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TILDEN, Professor W. A., F.R.S.
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WOLFE-BARRY, Sir JOHN, K.C.B., F.R.S.
WOODWARD, Dr. A. SMITH, F.R.S.

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The Trustees, the President and President Elect, the Presidents of former years, the Vice-Presidents and Vice-Presidents Elect, the General and Assistant General Secretaries for the present and former years, the General Treasurers for the present and former years, and the Local Treasurer and Secretaries for the ensuing Meeting.

TRUSTEES (PERMANENT).

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The Right Hon. Lord RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S.
Sir ARTHUR W. RÜCKER, M.A., D.Sc., F.R.S.

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Prof. A. W. Williamson, F.R.S.
Lord Avebury, D.C.L., F.R.S.
Lord Rayleigh, D.C.L., F.R.S.
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Sir A. W. Rücker, D.Sc., F.R.S.
Prof. J. Dewar, LL.D., F.R.S.

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Prof. A. W. Williamson, F.R.S.
A. Vernon Harcourt, Esq., F.R.S.
Sir A. W. Rücker, D.Sc., F.R.S.
Prof. R. A. Sohäfer, F.R.S.
Dr. D. H. Scott, M.A., F.R.S.

AUDITORS.

E. W. Brabrook, Esq., C.B.
L. L. Price, Esq., M.A.

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Report of the Council for the Year 1902–1903, *presented to the General Committee at Southport on Wednesday, September* 9, 1903.

The following resolutions were referred to the Council by the General Committee for consideration, and action if desirable :—

I. 'That the Council be requested to impress upon His Majesty's Government the desirability of appointing an Inspector of Ancient Monuments under the Ancient Monuments Act in the place of the late Lieut.-General Pitt-Rivers.'

II. 'That the Council be requested to call the attention of His Majesty's Government to the destruction of Ancient Monuments, especially on Dartmoor, which is authorised under the terms of the Highway Act, 5 & 6 Wm. IV., c. 50, the provisions of which are unrepealed by later Acts; and to urge the repeal of this section of the Act.'

III. 'That the attention of the Royal Irish Academy be drawn to the importance of organising and carrying out a Pigmentation Survey of School Children in Ireland.'

A Committee, consisting of the General Officers and Dr. A. C. Haddon, was appointed to draw up a Memorandum to give effect to these resolutions, and with the approval of the Council the following letter was addressed to the First Commissioner of Works and Public Buildings :—

'British Association for the Advancement of Science,
'Burlington House, London, W.,
'March 31, 1903.

'Sir,—I am desired by the Council of the British Association for the Advancement of Science to inform you that in their opinion it is very desirable that an Inspector under the Ancient Monuments Act be appointed in succession to the late General Pitt-Rivers.

'Since the death of the late Inspector of Ancient Monuments there is no one with scientific knowledge of the subject whose business it is to superintend the operations of the Act.

'The ancient monuments of Great Britain as a whole are not subject to any regular official inspection, and this lack of a personal interest in the monuments generally results in their neglect by their owners and by local authorities. The Council feel confident if an active and enthusiastic scientific Inspector of Ancient Monuments were appointed many more monuments would be placed under the Act, and would thereby be preserved for and by the nation.

'I have the honour to be your obedient Servant,
(Signed) 'James Dewar, *President.*'

To this letter the following reply was received :—

'H.M. Office of Works, April 8, 1903.

'Sir,—With reference to your letter of the 31st ultimo I am directed by the First Commissioner of His Majesty's Works, &c., to acquaint you,

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for the information of the Council of the British Association, that the question of the appointment of an Inspector under the Ancient Monuments Act is now engaging the attention of the Board.

'I am, Sir, your obedient Servant,
(Signed) 'SCHOMBERG K. MCDONNELL.'

On the Resolution II. the following letter was, with the approval of the Council, addressed to the President of the Local Government Board :—

'British Association for the Advancement of Science,
'Burlington House, London, W.,
'March 31, 1903.

'SIR,—I am desired by the Council of the British Association for the Advancement of Science to call your attention to the fact that in different parts of the country, and especially on Dartmoor, much damage has been and is still being done to Ancient Monuments by the materials of which they are constructed being taken for mending roads in the vicinity under cover of the Highway Act, 5 & 6 Wm. IV., c. 50, ss. li.–liv.

'As the surface stones near to the highways become used up, and road-mending material has to be brought from greater distances, the destruction of Ancient Monuments, particularly those in the vicinity of the highways, has proceeded apace by the hands of the contractors' *employés*.

'The Council desire in the name of this Association to express their opinion that the Act above mentioned should be amended, or other means taken to secure as speedily as possible the protection of Ancient Monuments of all kinds from further destruction in the manner indicated.

'I am, Sir,
'Your obedient Servant,
(Signed) 'JAMES DEWAR.

'To the Rt. Hon.
'President of the Local Government Board.'

To the above letter the following replies have been received :—

'Local Government Board,
'Whitehall, S.W., April 22, 1903.

'SIR,—I am directed by the Local Government Board to advert to your letter of the 31st ultimo with respect to the protection of Ancient Monuments and to state that the amendment of the Highway Act suggested in your letter will be noted by the Board.

'I am to add that, having regard to the provisions of the Ancient Monuments Protection Acts, the Board have sent a copy of your letter to the Commissioners of Works.

'I am also to suggest that, looking to the terms of the Ancient Monuments Protection Act of 1900, the Association might bring the matter under the notice of the respective County Councils.

'I am, Sir,
'Your obedient Servant,
(Signed) 'H. C. HOWES,
'*Assistant Secretary.*

'Professor Dewar, F.R.S.'

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'H.M. Office of Works,
'April 30, 1903.

'SIR,—A copy of your letter of the 31st ultimo to the President of the Local Government Board having been forwarded to this Department, I am directed by the First Commissioner of His Majesty's Works, &c., to state that it appears to this Board that the prevention of the damage to Ancient Monuments, to which you invite attention, is a matter in which the County Councils could most effectively take action, certain powers being conferred on those bodies by the Ancient Monuments Act 1900 (63 & 64 Vic., c. 34).

'I am, Sir,
'Your obedient Servant,
(Signed) 'SCHOMBERG K. MCDONNELL.

'Professor Dewar, F.R.S.'

On the Resolution III. the following letter was addressed, with the approval of the Council, to the President of the Royal Irish Academy :—

'British Association for the Advancement of Science,
'Burlington House, London, W.,
'March 31, 1903.

'DEAR SIR,—I am desired by the Council to inform you that at the meeting of the British Association for the Advancement of Science held last year at Belfast the question of the desirability of organising a Pigmentation Survey of the School Children in Ireland was discussed on the reading of a paper on that subject by Mr. J. F. Tocher, a copy of which is herewith inclosed.

'The Council venture to hope that the Royal Irish Academy, having for many years interested itself practically in the investigation of the Ethnography of Ireland, will carefully consider the scheme outlined in the paper, and may be induced to take up the work.

'The Council are of opinion that as a Pigmentation Survey of the School Children in Scotland is at present being conducted, a corresponding survey of the School Children in Ireland would be of considerable scientific value, and could not be carried out under better auspices than those of the Royal Irish Academy.

'I am, Sir,
'Yours faithfully,
(Signed) 'JAMES DEWAR, *President.*

'To the President of the
'Royal Irish Academy, Dublin.'

The following letter was received from the Colonial Secretary for Bermuda :—

'Colonial Secretary's Office, Hamilton, Bermuda,
'October 17, 1902.

'SIR,—I am directed by His Excellency the Governor of Bermuda to request you to be good enough to submit the following matter for the consideration of the British Association for the Advancement of Science.

'A Committee of the Legislature of this Colony, appointed to consider and report what steps it would be desirable to take locally with a view to the establishment and maintenance of a Marine Biological Station in these islands, has reported in favour of the establishment of such a station, and has recommended that the Legislature should make provision for its

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erection and ordinary equipment. This report has been adopted by the House of Assembly.

'The Committee has in its report further recommended that before the Legislature decides to take any definite action in the matter steps should be taken to endeavour to ascertain whether certain eminent scientific bodies and institutions both in the United Kingdom and in the United States of America would view with approval the establishment of such a station in these islands for purposes of scientific research, and to inquire also to what extent such institutions would be prepared to co-operate with this Colony in the matter, and to assist in making the station one of an international character and suitable for the prosecution of advanced scientific research.

'It is possible that the British Association might consider it desirable to encourage the establishment and maintenance of the proposed Biological Station, and I am requested to invite you to be good enough to submit this communication to that body for their information and consideration.

'I have the honour to be, Sir,

'Your obedient Servant,

(Signed) 'EYRE HUTSON,

'*Colonial Secretary.*'

The letter was referred to a Committee consisting of Professor Howes, Dr. Ray Lankester, Professor Herdman, Mr. G. Murray, and the General Officers, from whom the following report was received :—

'The Committee have to report that in their opinion the establishment of a Marine Biological Laboratory at Bermuda is very desirable, the island being most favourably situated for the purpose, inasmuch as it permits of the study of coral reefs and the many other interesting forms and problems of marine life associated therewith under climatic conditions excellently adapted for European workers.

'It appears from the letter of the Colonial Secretary of Bermuda that the Legislature of the Colony has resolved to erect and equip the laboratory, and that the support asked for is a contribution in the form of a grant or grants towards its maintenance.

'The Committee consider it desirable that the attention of the Committees of Sections concerned in marine problems of research be directed to the matter for the purpose of determining whether any definite researches could be usefully engaged in at the laboratory under the auspices of the Association, and to what degree these may be usefully advanced by the appropriation of the funds of the Association.

'The Committee are of opinion that in return for any subsidy given arrangements should be made with the Colonial Government to give accommodation and special facilities in the laboratory to workers appointed by the British Association.'

The report was adopted by the Council and has been referred to the Organising Committees of Sections for the consideration of those Sections interested in marine problems of research at the Southport Meeting.

A considerable number of notifications of alterations in coast outline having been received from the coastguard stations of the United Kingdom, the Committee on Coast Erosion, consisting of Sir Archibald Geikie,

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Captain Creak, Professor L. Vernon Harcourt, Mr. Whitaker, Mr. A. T. Walmisley, and the General Officers, were reappointed.

On the recommendation of the Committee, the Council asked Mr. John Parkinson, F.G.S., of Cambridge, to undertake the tabulation of the returns at a fee of ten guineas, and a further sum of 5*l.* was placed at the disposal of the Committee for expenses in connection with the work.

A valuable report and map have been prepared by Mr. Parkinson, which the Committee have incorporated in their report to the Council. The Council recommend that the report be read in the Geological Section at Southport, and published in the Report of the Association, and that the Lords of the Admiralty be apprised of the valuable information which has been collected with their assistance and co-operation.

The following letter was received from the then Secretary of the Corresponding Societies Committee :—

'British Association for the Advancement of Science,
'Burlington House, London, W.,
'July 4, 1902.

'DEAR SIRS,—The Corresponding Societies Committee are of opinion that some improved means of giving information to the Societies as to how they can aid by local investigations the work of Committees is very desirable.

'By the present arrangements the Societies are little more than placed in a position to communicate with those from whom they can obtain information regarding the work they could undertake.

'My Committee therefore desire to suggest that each of the Organising Committees of Sections be asked to consider what local work could be usefully undertaken by Corresponding Societies, and draw up a programme of that work, with directions as to the method of doing it, which in course would come before the Sectional Committee, and be forwarded for communication to the Conference of Delegates. The schemes of the several Sections would then be incorporated in the Report of the Conference sent to the Societies after the Meeting, and so come directly to their notice.

'If this suggestion be approved of by the Council, my Committee desire to further suggest that it could be best given effect to by direct communication from the Council to the Organising Committees of Sections.

'I am, yours faithfully,
J. G. GARSON.

'The General Secretaries,
'British Association.'

The letter was referred to a Committee, consisting of the President, President-elect, the General Officers, Professor Armstrong, Professor Meldola, and Professor Perry, to consider, and to report thereon to the Council.

The Committee recommended —

'1. That the work at present intrusted to the Secretaries of the Sectional Committees under Rule X. should devolve upon the Organising Committees.

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'2. That an official invitation on behalf of the Council be addressed to the Societies, through the Corresponding Societies Committee, asking them to appoint standing British Association Sub-Committees to be elected by themselves with the object of dealing with all those subjects of investigation common to their Societies and to the British Association Committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres.

'They appended the following remarks to their recommendation :—

'The Committee have considered the communication from the Corresponding Societies Committee referred to them by the Council, and have examined into the general character of the work carried on by the Corresponding Societies, and the nature of the subjects discussed at the Conferences of Delegates held annually under the auspices of the British Association since the year 1885. They are of opinion that the range of subjects very fairly covers most of the branches of scientific investigation in which local Societies might be expected to bear a part. New subjects are added from time to time, and means have been taken by the Corresponding Societies Committee to give publicity to suggestions for any suitable line of investigation instigated by the Corresponding Societies themselves. Of the numerous branches of inquiry being carried on by British Association Committees in which the Corresponding Societies are invited year by year to take a part, some have been materially assisted by the Corresponding Societies or their individual members. The subjects suitable for investigation by local Societies are necessarily governed in their scope by local conditions, but among those already brought under the notice of the Corresponding Societies there are some of a general character which might very well be taken up systematically all over the country. The Committee do not consider it necessary to furnish the Council with a complete list of such specific subjects, as these are already included in the various Reports of the Corresponding Societies Committee. They desire, however, to call the attention of the Council to the necessity for systematic co-operation among the local Societies for the carrying out of investigations of such general importance as the various surveys, archæological, ethnographic, photographic, and botanical, which have on several occasions been brought under the notice of the Corresponding Societies at the Conference of their Delegates. These and other investigations of a similarly wide range which may from time to time be suggested furnish ample work for the Corresponding Societies, and the Committee find that in certain districts considerable progress has been already made, or that steps are now being taken to organise the work already suggested.

'The Committee have further considered the nature of the organisation at present in existence for bringing the official representative of the Corresponding Societies into communication with each other and with the Sectional Committees at the meetings of the Association, and they are of opinion that it would tend to bring about a more systematic co-ordination of the general investigations which are now being carried on, or which it is desirable should be carried on, by the Corresponding Societies if strenuous efforts were made to bring the Delegates into more intimate personal relationship with the expert organisers of these various subjects

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of general interest to all local Societies. The Rules at present provide[1] for such co-operation between the Sectional Committees (through their Secretaries) and the Conference of Delegates; but your Committee are of opinion that, owing to the stress of work thrown upon the Sectional Secretaries at the meetings of the Association, the Delegates cannot derive the full benefit of such expert assistance as they may require in connection with particular lines of work in which their Societies are engaged. For the same reason the Secretaries of the Sections are unable to give full effect to any new schemes suitable for local investigation which may originate in their Section, and which, if duly considered beforehand and brought under the notice of the Delegates, might be of use both to the Corresponding Societies and to the Association. Your Committee recommend, therefore, that the work at present entrusted to the Secretaries of the Sectional Committees under Rule X. should devolve upon the Organising Committees. These Committees already comprise the Sectional Secretaries by virtue of their constitution,[2] so that no additional work would be thrown upon these Secretaries, but the gentlemen undertaking this office would be enabled to give more deliberate consideration to the work of the Corresponding Societies and to ensure before the meeting of the Association that their various Sectional Committees, as well as the originators of investigations requiring the co-operation of the Corresponding Societies, shall be fully and authoritatively represented at the Conference of Delegates. Your Committee propose, in order to give practical effect to this suggestion, that the opening clause of Rule 10 relating to Corresponding Societies be modified so as to read :—

> ' "The Organising Committees of each Section shall be instructed to transmit to the Secretaries of the Sections, and through these to the Secretaries of the Conference of Delegates, copies of any recommendation, &c." '

'Notice of this modification, if approved by the Council as recommended by your Committee, must be brought before the General Committee at the next meeting.

'In view of the increasing importance of science to the nation at large, your Committee desire to call the attention of the Council to the fact that in the Corresponding Societies the British Association has gathered in the various centres represented by these Societies practically all the scientific activity of the provinces. The number of members and Associates at present on the list of the Corresponding Societies approaches 25,000, and no organisation is in existence anywhere in the country better adapted than the British Association for stimulating, encouraging, and co-ordinating all the work being carried on by the seventy Societies at present enrolled. Your Committee are of opinion that further encouragement should be given to these Societies and their individual working members by every means within the power of the Association, and with the object of keeping the Corresponding Societies in more permanent touch with the Association they suggest that an official invitation on behalf of the Council be addressed to the Societies through the Corresponding Societies Committee asking them to appoint stand-

[1] Rule 10, Corresponding Societies.

[2] Rule XC.

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ing British Association Sub-Committees to be elected by themselves with the object of dealing with all those subjects of investigation common to their Societies and to the British Association Committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres. Your Committee may point out that the only permanent bodies carrying out systematic scientific work under the auspices of the Association are the various Committees appointed by the Sections to undertake particular investigations and to report thereon to their respective Sections. The proposal now submitted is equivalent to a request that the Corresponding Societies should themselves appoint such Standing Committees for stimulating every branch of inquiry in which these Societies are co-operating with the Association. It is believed that the active workers in every Society would by this means be brought to realise more fully that their labours are contributing to the general advancement of science; and since the subjects at present brought under the notice of the Corresponding Societies cover practically every department of science represented by the Sections of the Association, it is hoped that these new British Association Sub-Committees of the Corresponding Societies may serve as nuclei for creating and maintaining locally public interest in every branch of scientific knowledge.

'Your Committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the Corresponding Societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the Corresponding Societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the Education Committees now being appointed under the new Act. The Educational Section of the Association having been but recently added, the Corresponding Societies have as yet not had much opportunity for taking part in this branch of the Association's work, and in view of the reorganisation in education now going on all over the country your Committee are of opinion that no more opportune time is likely to occur for the influence of scientific organisations to make itself felt as a real factor in national education. They do not at the present juncture think it desirable to formulate any definite scheme detailing precise methods by which the Corresponding Societies might be of service to the cause of scientific education. Some Societies might prefer to unite to form Educational Consultative Committees of their own, and to place their services at the disposal of the Education Authority of their County or Borough. Others might prefer that individual members of their Societies should be added to the Education Committee, and others again might prefer to act indirectly by helping to foster public opinion in favour of that kind of education which it is the chief function of a scientific corporation such as the British Association to promote. In view of the importance which your Committee attach to this branch of the work now proposed for the Corresponding Societies, it is suggested that the circular issued by the Council in accordance with the recommendation in this Report should invite special expressions of opinion from the Societies through their Delegates at the next Conference at Southport, so that if it is considered desirable that local effort in the cause not only of Science but also of scientific education would be strengthened if backed up by the authority of the Association, the

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necessary steps may be taken by the Council to bring pressure to bear upon the Educational Committees through the Board of Education.

'The standing British Association Sub-Committees of and appointed by the Corresponding Societies, whether for educational or any other branch of work, would, through the Corresponding Societies Committee, be in touch with the Association, and it would always be open for these Sub-Committees to forward to the Corresponding Societies Committee suggested subjects for investigation or for discussion at the Conference. Your Committee are also of opinion that it would help to reassure the Corresponding Societies that the Association has a real interest in their welfare if the General Officers of the Association were made members *ex officio* of the Corresponding Societies Committee, so that they might keep in touch with the work of this Committee and also take part in the Conference of Delegates, and they recommend that in future the Council in nominating the members of this Committee add the General Officers to the list.'

The Council recommend that the opening clause of Rule 10, relating to Corresponding Societies, be modified so as to read :—

> ' "The Organising Committees of each Section shall be instructed to transmit to the Secretaries of the Sections, and through these to the Secretaries of the Conference of Delegates, copies of any recommendations, &c." '

On the invitation of the Organising Committee of the International Congress for Applied Chemistry, to be held in June 1903 at Berlin, the Council appointed the President (Professor James Dewar), Sir Henry Roscoe, and Professor Meldola to represent the British Association as Delegates.

The Council have nominated the Right Hon. the Earl Spencer, K.G., LL.D., Chancellor of the Victoria University, the Right Hon. the Earl of Sefton, Sir George Pilkington, Alfred Hopkinson, LL.D., K.C., Vice-Chancellor of the Victoria University, and Mr. E. Marshall Hall, K.C., M.P., Vice-Presidents of the Association for the Meeting at Southport.

The Council nominate Mr. W. Whitaker B.A., F.R.S., Chairman ; the Rev. J. O. Bevan, M.A., Vice-Chairman ; and Mr. F. W. Rudler, Secretary, to the Conference of Delegates of the Corresponding Societies, to be held during the Meeting at Southport.

A Report from the Corresponding Societies Committee for the past year, together with the list of the Corresponding Societies and the titles of the more important papers, especially those referring to Local Scientific Investigations, published by those Societies during the year ending May 31, 1903, has been received.

The Corresponding Societies Committee, consisting of Mr. W. Whitaker (Chairman), Mr. F. W. Rudler (Secretary), Professor R. Meldola, Mr. T. V. Holmes, Sir John Evans, Mr. J. Hopkinson, Dr. H. R. Mill, Mr. Horace T. Brown, Rev. J. O. Bevan, Professor W. W. Watts, Rev. T. R. R. Stebbing, Mr. C. H. Read, Dr. Vaughan Cornish, and the General Officers of the Association, are hereby nominated for reappointment by the General Committee.

The Council nominate the Right Honourable Arthur James Balfour, D.C.L., F.R.S., as President for the Cambridge meeting in 1904.

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An invitation for the Meeting of 1905 will be presented from Cape Town. After very full consideration of the matter the Council recommend that the invitation to hold the Annual Meeting of the Association in South Africa in 1905 be accepted.

The President having approached Sir Donald Currie with the object of ascertaining how far transit rates to South Africa might be reduced on behalf of the Association and its Members, received the following letter in reply :—

'4 Hyde Park Place, London, W.,
'June 11, 1903.

'DEAR PROFESSOR DEWAR,—With reference to the call with which you favoured me the other day and to our interview of this morning, I write to let you know that, as I have to leave for Scotland to-morrow, I shall now put in writing the arrangement which I propose in order to carry out your wishes on behalf of the Association.

'I understand from you that the Association contemplate a visit to South Africa the year after next, and that you have to some extent made the necessary preparations, but that you have been very anxious to have the assurance from me that the terms for the conveyance of the Members of the Council and their friends shall be such as can have your entire approval, and enable you to have a successful visit to South Africa of a representative character.

'Further, I understand from you that it is possible that other friends will be prepared to assist the funds which will be required to make the visit successful and not onerous to those who may engage in it.

'You have suggested that you will call the Council together and that I may be invited to meet them at Burlington House, but owing to the bereavement we have suffered I am hardly likely to be able to get back to London for the time you have suggested, hence the desire which I had to let you know in writing and without delay what I have to say in order to assist you in the proposed visit of the Association to South Africa. In the first place, in regard to the terms, I propose to you that our Mail Company shall make a reduction of 30 per cent. upon the ordinary return fares which we charge to the public, this reduction to be in favour of the official Delegates. In addition, ordinary Members of the Association and members of their families may wish to accompany them, and for their passage I propose that the price shall be reduced 25 per cent.

'It is very gratifying to me to be in a position to assist. I am well aware of the immense impetus that has been given to scientific investigation in the United Kingdom by the annual meetings of this Association; and it is thoroughly in accord with the spirit of Imperialism that the Mother Country should encourage Colonial scientific effort by a visit of the British Association to South Africa. There is another reason I am happy to be of service to that body of vigorous workers who by their investigations advance their respective sciences, and by their lectures and teaching keep us in touch with the progress made in this country and in others.

'The efforts of such intelligent workers as yourselves are not prompted by a love of gain and a spirit of commercial enterprise, and I venture to say that all who have received practical advantages and benefits from such researches, studies, and developments should be ready to acknowledge gratefully your successes in every way in their power.

'I can lay no claim personally to having taken any part in such scientific research; but it has fallen to my lot during the many years I have been connected with steamship enterprise and Colonial mining work,

in which I am largely interested, to take advantage, as I have said, of the lessons in practical science which the exertions of scientists have developed. In regard to the material for the construction of ships, whether of steel or of iron, to the advance in naval architecture, to the adaptation of power to produce suitable results, to the inquiry into the means of securing the maximum advantage in the consumption of fuel, to the application of electricity as a motive and illuminative power, and to the utilisation of telegraphy in all its forms, men like myself who have been benefited by the practical application of such discoveries are really bound to do all we can to assist you in any scheme such as you now contemplate to enlarge the scope of your aims and operations.

'In addition to the terms for the conveyance of yourselves and friends of the deputation to and from South Africa, which you will approve of as favourable, I shall be glad to subscribe 500*l.* to any fund which you will, I think, find it desirable to collect in order that all the expenses of your visit to South Africa may be fully covered.

'Believe me, yours very truly,

'DONALD CURRIE.

'Professor Dewar,
'President of the British Association.'

To this letter the following reply was sent :—

'British Association for the Advancement of Science,
'Burlington House, London, W., June 12, 1903.

'DEAR SIR DONALD CURRIE,—I am in receipt of your most noble response to my appeal for aid and support on behalf of the project of a visit of the British Association for the Advancement of Science to South Africa in the year 1905, and will forthwith communicate the same to the Council. May I at once, as the President, express on behalf of the Council and the Association the profound gratitude which I am sure they would desire me to convey for your generous appreciation of the work of Science, and the helpful and fatherly way in which you have responded to pecuniary difficulties.

'Yours very faithfully,

'JAMES DEWAR.

The Council have received the following important letter from Sir Frederick Bramwell, Bart., F.R.S., which they desire to record in their Report :—

'5 Great George Street, Westminster, S.W.,
'July 2, 1903.

'MY DEAR PRESIDENT,—It may, perhaps, be in the recollection of a few of the older Members of Section G that, at the Jubilee Meeting, York, 1881, I said (in a "communication" ordered to be printed *in extenso*), speaking of the Steam Engine, that "a change in the production of power from fuel appears to be impending, if not in the immediate future, at all events in a time not very far remote ; and however much the Mechanical Section of the British Association may to day contemplate with regret even the mere distant prospect of the Steam Engine becoming a thing of the past, I very much doubt whether those who meet here fifty years hence will then speak of that motor except in the character of a curiosity to be found in a museum."[1]

[1] *British Association Proceedings*, 1881 Volume, page 505.

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'In saying this, I no doubt then thought I was speaking somewhat hyperbolically, but from the close attention I have paid to the subject of internal-combustion engines, and from the way in which that attention has revealed a continuous and, year by year, a largely increasing development of such engines, I feel assured that although there may still be steam engines remaining in work in 1931, the output of steam engines in that year will be but small as compared with the output of internal-combustion engines.

'I wish to keep alive the interest of the Association in this subject, and for this purpose I should be glad to be allowed to now present to the Association 50*l.*, which I suggest should be invested in 2½ per cent. Self-accumulative Consols, amounting in 1931 to about 100*l.*, which sum, or whatever other sum may be to the credit of the account at that time, I should like to be paid as an honorarium to a gentleman to be selected by the Council to prepare a Paper having my utterances in 1881 as a sort of text, and dealing with the whole question of the prime movers of 1931, and especially with the then relation between steam engines and internal-combustion engines.

'I enclose a cheque drawn in your favour for 50*l.*

'Believe me to be, yours very truly,

'FREDERICK BRAMWELL.

'Professor James Dewar, M.A., LL.D, F.R.S., &c., &c.,
'President of the British Association for the Advancement of Science.'

The Council, having been informed by Dr. D. H. Scott that he does not intend to offer himself for re-election as General Secretary after the Southport Meeting, desire to record their sense of the valuable services he has rendered to the Association during the years he has held that office.

The Council recommend that Professor W. A. Herdman, D.Sc., F.R.S., be appointed General Secretary in succession to Dr. D. H. Scott.

In accordance with the regulations the retiring Members of the Council will be :—

By Seniority.	*By least Attendance.*
Captain E. W. Creak.	Sir Oliver Lodge.
Hon. Sir C. W. Fremantle.	Professor Sollas.
Professor W. D. Halliburton.	

The Council recommend the re-election of the other ordinary Members of the Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list :—

Abney, Sir W., K.C.B., F.R.S.
Armstrong, Professor H. E., F.R.S.
Bonar, J., Esq., LL.D.
*Bourne, G. C., Esq., M.A.
Bower, Professor F. O., F.R.S.
*Brabrook, E. W., Esq., C.B.
Callendar, Professor H. L., F.R.S.
Cunningham, Professor D. J., F.R.S.
Darwin, Major L., Sec. R.G.S.
Gotch, Professor F., F.R.S.
Haddon, Dr. A. C., F.R.S.
Hawksley, C., Esq., M.Inst.C.E.
Howes, Professor G. B., F.R.S.
Keltie, J. Scott, Esq., LL.D.
Macalister, Professor A., F.R.S
*McKendrick, Professor J. G., F.R.S.
*Noble, Sir A., Bart., K.C.B., F.R.S.
Petkin, Professor W. H., F.R.S.
Perry, Professor John, F.R.S.
Price, L. L., Esq., M.A.
Seward, A. C., Esq., F.R.S.
Tilden, Professor W. A., F.R.S.
Watts, Professor W. W., F.G.S.
Wolfe-Barry, Sir John, K.C.B., F R.S.
*Woodward, Dr. A. S., F.R.S.

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COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE SOUTHPORT MEETING IN SEPTEMBER 1903.

1. *Receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee	Grants
SECTION A.—MATHEMATICS AND PHYSICS.		
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements	*Chairman.*—Lord Rayleigh. *Secretary.*—Dr. R. T. Glazebrook. Lord Kelvin, Professors W. E. Ayrton, J. Perry, W. G. Adams, and G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Professors J. D. Everett and A. Schuster, Dr. J. A. Fleming, Professor J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Professor S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir A. W. Rücker, Professor H. L. Callendar, and Mr. G. Matthey.	£ s. d. Balance in hand.
Seismological Observations.	*Chairman.*—Professor J. W. Judd. *Secretary.*—Mr. J. Milne. Lord Kelvin, Professor T. G. Bonney, Mr. C. V. Boys, Professor G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Professor J. A. Ewing, Dr. R. T. Glazebrook, Professor C. G. Knott, Professor R. Meldola, Mr. R. D. Oldham, Professor J. Perry, Mr. W. E. Plummer, Professor J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson, and Professor H. H. Turner.	40 0 0
To co-operate with the Royal Meteorological Society in initiating an Investigation of the Upper Atmosphere by means of Kites.	*Chairman.*—Dr. W. N. Shaw. *Secretary.*—Mr. W. H. Dines. Mr. D. Archibald, Mr. C. Vernon Boys, Dr. A. Buchan, Dr. R. T. Glazebrook, Dr. H. R. Mill, and Dr. A. Schuster.	50 0 0 and balance in hand.
To co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*— Dr. R. T. Glazebrook. Professor W. G. Adams, Captain Creak, Mr. W. F. Fox, Professor A. Schuster, and Sir A. W. Rücker.	60 0 0

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1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
SECTION B.—CHEMISTRY.		
Preparing a new Series of Wave-length Tables of the Spectra of the Elements.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Dr. Marshall Watts. Sir Norman Lockyer, Professors J. Dewar, G. D. Liveing, A. Schuster, W. N. Hartley, and Wolcott Gibbs, Sir W. de W. Abney, and Dr. W. E. Adeney.	£ s. d. 10 0 0
The Study of Hydro-aromatic Substances.	*Chairman.*—Professor E. Divers. *Secretary.*—Dr. A. W. Crossley. Professor W. H. Perkin, Dr. M. O. Forster, and Dr. Le Sueur.	25 0 0
SECTION C.—GEOLOGY.		
To investigate the Erratic Blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. P. F. Kendall. Professor T. G. Bonney, Mr. C. E. De Rance, Professor W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker, and Mr. F. W. Harmer.	10 0 0 and balance in hand.
To explore Irish Caves. (Collections to be placed in the Science and Art Museum, Dublin.)	*Chairman.*—Dr. R. F. Scharff. *Secretary.*—Mr. R. Lloyd Praeger. Mr. G. Coffey, Professor Grenville Cole, Dr. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, and Mr. R. J. Ussher.	Balance in hand.
The movements of Underground Waters of North-west Yorkshire.	*Chairman.*—Professor W. W. Watts. *Secretary.*—Mr. A. R. Dwerryhouse. Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. G. Bray, Rev. W. Lower Carter, Mr. T. Fairley, Professor P. F. Kendall, and Mr. J. E. Marr.	Balance in hand.
To study Life-zones in the British Carboniferous Rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. J. T. Stobbs, Mr. A. Strahan, and Dr. H. Woodward.	35 0 0

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1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants £ s. d.
To report upon the Fauna and Flora of the Trias of the British Isles.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Mr. J. Lomas. Professors W. W. Watts and P. F. Kendall, and Messrs H. C. Beasley, E. T. Newton, A. C. Seward, and W. A. E. Ussher.	10 0 0
To investigate the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.	*Chairman.*—Mr. G. W. Lamplugh. *Secretary.*—Mr. J. W. Stather. Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Messrs. A. R. Dwerryhouse, F. W. Harmer, and J. H. Howarth, Rev. W. Johnson, and Messrs. P. F. Kendall, E. T. Newton, H. M. Platnauer, Clement Reid, and T. Sheppard.	50 0 0
Section D.—ZOOLOGY.		
To aid competent Investigators selected by the Committee to carry on definite pieces of work at the Zoological Station at Naples.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Mr. J. E. S. Moore. Professor E. Ray Lankester, Professor W. F. R. Weldon, Professor G. B. Howes, Mr. A. Sedgwick, and Professor W. C. McIntosh.	100 0 0
Compilation of an Index Generum et Specierum Animalium.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Dr. F. A. Bather. Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Mr. R. McLachlan, and Mr. W. E. Hoyle.	60 0 0
To enable Mr. J. W. Jenkinson to continue his Researches on the Influence of Salt and other Solutions on the Development of the Frog.	*Chairman.*—Professor Weldon. *Secretary.*—Mr. J. W. Jenkinson. Professor S. J. Hickson.	15 0 0
To enable Dr. F. W. Gamble to conduct Researches on the Colour Physiology of Higher Crustacea.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Dr. F. W. Gamble. Dr. Hoyle and Dr. F. W. Keeble.	15 0 0
Section F.—ECONOMIC SCIENCE AND STATISTICS.		
The Accuracy and Comparability of British and Foreign Statistics of International Trade.	*Chairman.*—Dr. E. Cannan. *Secretary.*—Dr. B. Ginsburg. Mr. A. L. Bowley, Professor S. J. Chapman, Sir R. Giffen, and Mr. R. H. Inglis Palgrave.	25 0 0

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1. *Receiving Grants of Money*—continued

Subject for Investigation or Purpose	Members of the Committee	Grants
SECTION G.—ENGINEERING.		
To investigate the Resistance of Road Vehicles to Traction.	*Chairman.*—Sir J. I. Thornycroft. *Secretary.*—Professor H. S. Hele-Shaw. Mr. T. Aitken, Mr. T. C. Aveling, Professor T. Hudson Beare, Mr. W. W. Beaumont, Mr. J. Brown, Colonel R. E. Crompton, Mr. B. J. Diplock, Mr. A. Mallock, Professor J. Perry, Sir D. Salomons, Mr. A. R. Sennett, Mr. E. Shrapnell Smith, and Professor W. C. Unwin.	£ s. d. 90 0 0
SECTION H.—ANTHROPOLOGY.		
To conduct Archæological and Ethnological Researches in Crete.	*Chairman.*—Sir John Evans. *Secretary.*—Mr. J. L. Myres. Mr. R. C. Bosanquet, Mr. A. J. Evans, Mr. D. G. Hogarth, Professor A. Macalister, and Professor W. Ridgeway.	100 0 0
To investigate the Lake Village at Glastonbury, and to report on the best method of publication of the result.	*Chairman.*—Dr. R. Munro. *Secretary.*—Professor W. Boyd Dawkins. Sir John Evans and Messrs. Arthur J. Evans, C. H. Read, H. Balfour, and A. Bulleid.	25 0 0
To conduct Anthropometric Investigations among the Native Troops of the Egyptian Army.	*Chairman.*—Professor A. Macalister. *Secretary.*—Dr. C. S. Myers. Sir John Evans and Professor D. J. Cunningham.	10 0 0
To co-operate with Local Committees in Excavations on Roman Sites in Britain.	*Chairman.*—Dr. A. J. Evans. *Secretary.*—Mr. J. L. Myres. Professor Boyd Dawkins, Mr. E. W. Brabrook, and Mr. T. Ashby.	25 0 0
To organise Anthropometric Investigation in Great Britain and Ireland.	*Chairman.*—Professor D. J. Cunningham. *Secretary.*—Mr. J. Gray. Mr. Annandale, Dr. A. C. Haddon, Dr. C. S. Myers, Mr. J. L. Myres, Professor A. F. Dixon, Mr. E. N. Fallaize, Mr. Randall MacIver, Professor J. Symington, and Dr. Waterston.	Balance in hand.

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1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants £ s. d.
SECTION I.—PHYSIOLOGY.		
The State of Solution of Proteids.	*Chairman.*—Professor W. D. Halliburton. *Secretary.*—Professor E. Waymouth Reid. Professor E. A. Schäfer.	20 0 0
To enable Professor Starling, Professor Brodie, Dr. Hopkins, Mr. Fletcher, Mr. Barcroft, and others to determine the 'Metabolic Balance Sheet' of the Individual Tissues.	*Chairman.*—Professor Gotch. *Secretary.*—Mr. J. Barcroft. Sir Michael Foster and Professor Starling.	40 0 0
SECTION K.—BOTANY.		
To carry out the scheme for the Registration of Negatives of Botanical Photographs.	*Chairman.*—Professor L. C. Miall. *Secretary.*—Professor F. E. Weiss. Mr. Francis Darwin, Dr. W. G. Smith, and Mr. A. G. Tansley.	5 0 0
The Respiration of Plants.	*Chairman.*—Professor H. Marshall Ward. *Secretary.*—Mr. H. Wager. Mr. Francis Darwin and Professor J. B. Farmer.	15 0 0
To assist Mr. Alfred Fryer in the completion of a Monograph on the genus *Potamogeton*.	*Chairman*—Professor S. H. Vines. *Secretary.*—Dr. D. H. Scott. Professor H. Marshall Ward and Professor I. Bayley Balfour.	10 0 0
Experimental Studies in the Physiology of Heredity.	*Chairman.*—Professor H. Marshall Ward. *Secretary.*—Mr. A. C. Seward. Professor J. B. Farmer and Dr. D. Sharp.	35 0 0
CORRESPONDING SOCIETIES.		
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Sir John Evans, Rev. J. O. Bevan, Dr. H. T. Brown, Dr. Vaughan Cornish, Mr. T. V. Holmes, Mr. J. Hopkinson, Professor R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Prof. W. W. Watts, and the General Officers.	20 0 0

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2. *Not receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee
SECTION A.—MATHEMATICS AND PHYSICS.	
Co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.	*Chairman.*—Lord McLaren. *Secretary.*—Professor Crum Brown. Sir John Murray, Dr. A. Buchan, Professor R. Copeland, and Mr. Omond.
The Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water.	*Chairman* and *Secretary.*—Professor J. D. Everett. Lord Kelvin, Sir Archibald Geikie, Professor Edward Hull, Dr. C. Le Neve Foster, Professor A. S. Herschel, Professor G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. Edward Wethered, Mr. A. Strahan, Professor Michie Smith, Professor H. L. Callendar, and Mr. B. H. Brough.
Considering the best Methods of Recording the Direct Intensity of Solar Radiation.	*Chairman.*—Dr. G. Johnstone Stoney. *Secretary.*—Professor H. McLeod. Professor A. Schuster, Sir H. E. Roscoe, Captain Sir W. de W. Abney, Dr. C. Chree, Professor H. L. Callendar, Mr. W. E. Wilson, and Professor A. A. Rambaut.
The Consideration of the Teaching of Elementary Mechanics, and the Improvement which might be effected in such Teaching.	*Chairman.*—Professor Horace Lamb. *Secretary.*—Professor J. Perry. Mr. C. Vernon Boys, Professors Chrystal, Ewing, G. A. Gibson, and Greenhill, Principal Griffiths, Professor Henrici, Dr. E. W. Hobson, Mr. C. S. Jackson, Sir Oliver Lodge, Professors Love, Minchin, and Schuster, and Mr. A. W. Siddons.
That Miss Hardcastle be requested to continue her Report on the present state of the Theory of Point-groups.	
SECTION B.—CHEMISTRY.	
The Nature of Alloys.	*Chairman* and *Secretary.*—Mr. F. H. Neville Mr. C. T. Heycock and Principal E. H. Griffiths.
Isomeric Naphthalene Derivatives.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Professor H. E. Armstrong.
The Study of Isomorphous Sulphonic Derivatives of Benzene.	*Chairman.*—Professor H. A. Miers. *Secretary.*—Professor H. E. Armstrong. Dr. W. P. Wynne and Mr. W. J. Pope.

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2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
The Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.	*Chairman* and *Secretary*.—Professor W. Noel Hartley. Professor F. R. Japp, Professor J. J. Dobbie, and Mr. Alexander Lauder.
SECTION C.—GEOLOGY.	
The Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	*Chairman*.—Professor J. Geikie. *Secretary*.—Professor W. W. Watts. Professor T. G. Bonney, Dr. T. Anderson, Professors E. J. Garwood and S. H. Reynolds, and Messrs. A. S. Reid, W. Gray, H. B. Woodward, R. Kidston, J. J. H. Teall, J. G. Goodchild, H. Coates, C. V. Crook, G. Bingley, R. Welch, A. K. Coomáraswámy, and W. J. Harrison.
To report upon the present state of our Knowledge of the Structure of Crystals.	*Chairman*.—Professor N. Story Maskelyne. *Secretary*.—Professor H. A. Miers. Mr. L. Fletcher, Professor W. J. Sollas, Mr. W. Barlow, Mr. G. F. H. Smith, the Earl of Berkeley, and Mr. H. L. Bowman.
To promote the Registration of Type Specimens of Fossils in the British Isles.	*Chairman*.—Dr. H. Woodward. *Secretary*.—Dr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Professor H. G. Seeley, Mr. H. Woods, and Rev. J. F. Blake.
SECTION D.—ZOOLOGY.	
To investigate the structure, formation, and growth of the Coral Reefs of the Indian Region, with special observations on the inter-relationship of the reef organisms, the depths at which they grow, the food of corals, effects of currents and character of the ocean bottom, &c. The land flora and fauna will be collected, and it is intended that observations shall be made on the manners, &c., of the natives in the different parts of the Maldive group.	*Chairman*.—Mr. A. Sedgwick. *Secretary*.—Mr. J. Stanley Gardiner. Professor J. W. Judd, Mr. J. J. Lister, Mr. Francis Darwin, Dr. S. F. Harmer, and Professors A. Macalister, W. A. Herdman, and S. J. Hickson.
To enable Miss Igesna Sollas, of Newnham College, Cambridge, to study certain points in the development of Ophiusoids, and to enable other competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.	*Chairman and Secretary*.—Mr. W. Garstang. Professor E. Ray Lankester, Mr. A. Sedgwick, Professor Sydney H. Vines, and Professor W. F. R. Weldon.

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2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To continue the investigation of the Zoology of the Sandwich Islands, with power to co-operate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance in their investigations as may be offered by the Hawaiian Government or the Trustees of the Museum at Honolulu. The Committee to have power to dispose of specimens where advisable.	*Chairman.*—Professor A. Newton. *Secretary.*—Dr. David Sharp. Dr. W. T. Blanford, Professor S. J. Hickson, Dr. P. L. Sclater, Mr. F. Du Cane Godman, and Mr. Edgar A. Smith.
To conduct an Investigation into the Madreporaria of the Bermuda Islands.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Dr. W. E. Hoyle. Dr. F. F. Blackman, Mr. J. S. Gardiner, Professor W. A. Herdman, Mr. A. C. Seward, Professor C. S. Sherrington, and Mr. A. G. Tansley.
Section E.—GEOGRAPHY.	
Terrestrial Surface Waves.	*Chairman.*—Dr. J. Scott Keltie. *Secretary.*—Dr. Vaughan Cornish. Lieut.-Col. F. Bailey, Mr. E. A. Floyer, Mr. John Milne, and Mr. W. H. Wheeler.
The Geography of the Antarctic Regions in the area to be explored by the Scottish National Antarctic Expedition.	*Chairman.*—Sir T. H. Holdich. *Secretary.*—Lieut.-Col. F. Bailey. Mr. W. S. Bruce.
Section G.—ENGINEERING.	
To obtain Information respecting the present Tidal Régime of the River Mersey, with the object of submitting the data so obtained to Harmonic Analysis.	*Chairman.*—Lord Kelvin. *Secretary.*—Mr. J. N. Shoolbred. Professors G. H. Darwin, H. S. Hele-Shaw, Osborne Reynolds, and W. C. Unwin.
Section H.—ANTHROPOLOGY.	
To conduct Explorations with the object of ascertaining the Age of Stone Circles.	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. H. Balfour. Sir John Evans, Dr. J. G. Garson, Professor Meldola, Mr. A. J. Evans, Dr. R. Munro, Professor Boyd Dawkins, and Mr. A. L. Lewis.
The Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. J. L. Myres. Dr. J. G. Garson, Mr. H. Ling Roth, Mr. H. Balfour, Dr. A. C. Haddon, Mr. E. S. Hartland, Mr. E. Heawood, Mr. H. S. Kingsford, and Professor Flinders Petrie.

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2. Not receiving Grants of Money—continued.

Subject for Investigation or Purpose	Members of the Committee
The present state of Anthropological Teaching in the United Kingdom and elsewhere.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Mr. J. L. Myres. Professor A. Macalister, Dr. A. C. Haddon, Mr. C. H. Read, Mr. H. Balfour, Mr. F. W. Rudler, Dr. R. Munro, Professor Flinders Petrie, Mr. H. Ling Roth, and Professor D. J. Cunningham.
To organise an Ethnological Survey of Canada.	*Chairman.*—Professor D. P. Penhallow. *Secretary.*—Mr. C. Hill-Tout. Mr. E. W. Brabrook, Dr. A. C. Haddon, Mr. E. S. Hartland, Mr. B. Sulte, Mr. David Boyle, Mr. C. N. Bell, Professor E. B. Tylor, Professor J. Mavor, Mr. A. F. Hunter, Dr. W. F. Ganong, Rev. Father Monies, Rev. Father A. G. Morice, Mr. W. Crooke, and Mr. J. L. Myres.
To report on the present state of knowledge of the Ethnography, Folklore, and Languages of the Peoples of the Pacific.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Dr. A. C. Haddon. Mr. H. Balfour and Mr. J. Stanley Gardiner.

Section I.—PHYSIOLOGY.

The Physiological Effects of Peptone and its Precursors when introduced into the circulation.	*Chairman.*—Professor E. A. Schäfer. *Secretary.*—Professor W. H. Thompson. Professors R. Boyce and C. S. Sherrington.
To investigate the Functions of the Rods and Cones in the Mammalian Retina with reference to the Visual Purple.	*Chairman.*—Professor J. G. McKendrick. *Secretary.*—Dr. F. W. Edridge-Green. Professors E. H. Starling and A. D. Waller.

Section L.—EDUCATIONAL SCIENCE.

The conditions of Health essential to the carrying on of the work of instruction in schools.	*Chairman.*—Professor Sherrington. *Secretary.*—Mr. E. White Wallis. Dr. C. W. Kimmins, Professor L. C. Miall, Miss Findlay, Miss Alice Ravenhill, Miss Maitland, Dr. Clement Dukes, Dr. Rivers, Mr. J. Russell, Dr. Sydney Stephenson, Dr. C. Childs, Dr. C. Shelley, and Mr. E. W. Brabrook.
To consider and report upon the influence exercised by Universities and Examining Bodies on secondary school curricula, and also of the schools on university requirements.	*Chairman.*—Dr. H. E. Armstrong. *Secretary.*—Mr. R. A. Gregory. The Bishop of Hereford, Sir Michael Foster, Sir P. Magnus, Sir A. W. Rücker, Sir O. J. Lodge, Mr. H. W. Eve, Mr. W. A. Shenstone, Mr. W. D. Eggar, Professor Marshall Ward, Mr. F. H. Neville, Mrs. W. N. Shaw, and Dr. C. W. Kimmins.

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2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
The Teaching of Botany in Schools.	*Chairman.*—Professor L. C. Miall. *Secretary.*—Mr. Harold Wager. Professor J. R. Green, Mr. A. C. Seward, Professors H. M. Ward, J. B. Farmer, and T. Johnson, Miss Lilian Clarke, and Dr. C. W. Kimmins.
To report upon the Course of Experimental, Observational, and Practical Studies most suitable for Elementary Schools.	*Chairman.*—Sir Philip Magnus. *Secretary.*—Mr. W. M. Heller. Sir W. de W. Abney, Mr. R. H. Adie, Professor H. E. Armstrong, Miss A. J. Cooper, Miss L. J. Clarke, Mr. George Fletcher, Professor R. A. Gregory, Principal Griffiths, Mr. A. D. Hall, Mr. A. J. Herbertson, Dr. C. W. Kimmins, Professor J. Perry, Mrs. W. N. Shaw, Professor A. Smithells, Dr. Lloyd Snape, Principal Reichel, Mr. H. Richardson, Mr. Harold Wager, and Professor W. W. Watts.

Communication ordered to be printed in extenso.

On the Use of Vectorial Methods in Physics. By Professor Henrici, F.R.S.

Resolutions referred to the Council for consideration, and action if desirable.

(i.) 'That, as urged by the President in his Address, it is desirable that Scientific workers, and persons interested in Science, be so organised that they may exert permanent influence on public opinion, in order more effectively to carry out the third object of this Association originally laid down by the Founders, viz., "to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress," and that the Council be recommended to take steps to promote such organisation.'

(ii.) 'That the Council be requested to consider the desirability of urging upon the Government, by a deputation to the First Lord of the Treasury or otherwise, the importance of increased national provision being made for University Education.'

(iii.) 'The Committee of Section A, having received a communication from the International Meteorological Committee, is of opinion that the introduction of international uniformity in the units adopted for the records of meteorological observations would be of great practical advantage to Science, and that the Council be requested to take such steps as they may think fit toward giving effect to the resolution.'

[Translation of Extract from the Procès Verbal of the International Meteorological Committee at their Meeting on September 11, 1903, referred to above :—

'Section 6.—Dr. Shaw moved that the attention of Section A of the British Association be called by the International Meteorological Committee to the utility which would result from obtaining more uniformity in the units adopted in Meteorology, and to inquire if the Section did not consider that the moment had come for bringing about this uniformity.'

'After discussion, the Committee decided to call the attention of Section A of the British Association to the inconveniences which arise from the lack of uniformity in the units adopted in Meteorological observations, and to ask it to consider if the time has not come for bringing about this uniformity.']

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(iv.) 'The Committee of Section A desire to express their opinion that the systematic investigation of the upper currents of the atmosphere by means of kites or balloons is of great importance to Meteorology; and ask the Council to take such steps as they may think fit to urge upon the Treasury the importance of providing the Meteorological Council with the funds necessary for the purpose.'

(v.) 'That the Council be asked to consider the desirability of permitting the publication of the whole of the Sectional programmes in the 'Daily Journal' at as early a date as possible.'

(vi.) 'That it is desirable that further steps should be taken to make the Reports of Committees (as distinguished from papers) communicated to the Association more accessible to the general public by the provision of Indices to the published volumes and otherwise; and that the Council be asked to consider the conditions upon which Reports of Committees and Proceedings of Sections might be published separately if required.'

(vii.) 'That the Sectional Committees be continued in existence until the new Sectional Committees are appointed, and be authorised to bring to the notice of the Council in the interval between the Annual Meetings of the Association any matter on which the action of the Council may be desired in the interests of the several Sections, and that a Committee may be summoned at any time by the President of the Section or by the Council.'

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Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Southport Meeting, September 1903. *The Names of the Members entitled to call on the General Treasurer for the respective Grants are prefixed.*

Mathematics and Physics.

	£	s.	d.
*Rayleigh, Lord—Electrical Standards (Unexpended balance)	—		
*Judd, Professor J. W.—Seismological Observations	40	0	0
*Shaw, Dr. W. N.—Upper Atmosphere Investigations (Unexpended balance and)	50	0	0
*Preece, Sir W. H.—Magnetic Observations	60	0	0

Chemistry.

*Roscoe, Sir H.—Wave-length Tables of Spectra	10	0	0
*Divers, Prof. E.—Study of Hydro-Aromatics	25	0	0

Geology.

*Marr, Mr. J. E.—Erratic Blocks (Balance in hand and)	10	0	0
*Scharff, Dr. R. F.—To Explore Irish Caves (Balance in hand)	—		
*Watts, Professor W.—Movements of Underground Waters (Balance in hand)	—		
*Marr, Mr. J. E.—Life-zones in Carboniferous Rocks	35	0	0
*Herdman, Professor—Fauna and Flora of British Trias	10	0	0
Lamplugh, Mr. G. W.—To investigate Fossiliferous Drifts	50	0	0

Zoology.

*Hickson, Professor S. J.—Zoological Table at Naples	100	0	0
*Woodward, Dr. H.—Index Animalium	60	0	0
Weldon, Professor—Investigations in Development in the Frog	15	0	0
Hickson, Professor S. J.—Researches on the Higher Crustacea	15	0	0

Economic Science and Statistics.

Cannan, Dr. E.—British and Foreign Statistics of International Trade	25	0	0

Engineering.

*Thornycroft, Sir J. J.—Resistance of Road Vehicles to Traction	90	0	0
Carried forward	£595	0	0

* Reappointed.

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	£	s.	d.
Brought forward	595	0	0
Anthropology.			
*Evans, Sir John—Archæological and Ethnological Researches in Crete	100	0	0
*Munro, Dr. R.—Researches in Glastonbury Lake Village	25	0	0
*Macalister, Professor A.—Anthropometric Investigation on Egyptian Troops	10	0	0
Evans, Dr. A. J.—Excavations on Roman Sites in Britain	25	0	0
Physiology.			
*Halliburton, Professor—The State of Solution of Proteids	20	0	0
Gotch, Professor—Metabolism of Individual Tissues	40	0	0
Botany.			
Vines, Professor S. H.—Completion of Monograph on Potamogeton	10	0	0
*Miall, Professor L. C.—Botanical Photographs	5	0	0
*Ward, Professor Marshall—Respiration of Plants	15	0	0
Ward, Professor M.—Experimental Studies in Heredity	35	0	0
Corresponding Societies.			
*Whitaker, Mr. W.—Preparing Report, &c.	20	0	0
	£900	0	0

* Reappointed.

The Annual Meeting in 1904.

The Annual Meeting of the Association in 1904 will be held at Cambridge, commencing August 17.

The Annual Meeting in 1905.

The Annual Meeting of the Association in 1905 will be held in South Africa.

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General Statement of Sums which have been paid on account of Grants for Scientific Purposes

1834.

	£	s.	d.
Tide Discussions	20	0	0

1835.

	£	s.	d.
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0

1836.

	£	s.	d.
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on Long-continued Heat	17	1	0
Rain-gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0

1837.

	£	s.	d.
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6

1838.

	£	s.	d.
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2

1839.

	£	s.	d.
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	85	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	0
Cast-iron Experiments	103	0	7
Railway Constants	28	7	0
Land and Sea Level	274	1	2
Steam-vessels' Engines	100	0	4
Stars in Histoire Céleste	171	18	0
Stars in Lacaille	11	0	6
Stars in R.A.S. Catalogue	166	16	0
Animal Secretions	10	10	6
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0

1840.

	£	s.	d.
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

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1841.

	£	s.	d.
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Firth of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8

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	£	s.	d.
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment at Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology....1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment at Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

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1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

1851.

Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

Maintaining the Establishment at Kew Observatory:—			
1854 £75 0 0 1855 £500 0 0	575	0	0

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	£	s.	d.
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	0
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seed	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860.....£50 0 0 / 1861.....£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahagow	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

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1862.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland Coasts	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east Coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging, Shetland	75	0	0
Dredging, Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-gauges	19	15	8
Cast-iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

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1866.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall.....	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-bed ...	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation ...	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards.....	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast ...	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water.....	50	0	0
Polycyanides of Organic Radicals	29	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania.....	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches ...	30	0	0
Palestine Exploration Fund...	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Meteorological Instruments, Palestine.....	50	0	0
Lunar Committee	120	0	0
Metrical Committee.....	30	0	0
Kent's Hole Explorations ...	100	0	0
Palestine Explorations.....	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall.....	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-bed ...	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards.....	100	0	0
Ethyl and Methyl Series.....	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture...	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	120	0	0
Metrical Committee.....	50	0	0
Zoological Record.....	100	0	0
Kent's Hole Explorations ...	150	0	0
Steamship Performances . ..	100	0	0
British Rainfall.....	50	0	0
Luminous Meteors.....	50	0	0
Organic Acids	60	0	0
Fossil Crustacea.....	25	0	0
Methyl Series.....	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall..	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature...	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall.....	50	0	0
Thermal Conductivity of Iron, &c.....	30	0	0
Kent's Hole Explorations.....	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron.....	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series.....	30	0	0
Organic Remains in Limestone Rocks.....	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature...	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0

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	£	s.	d.
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

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1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorology	100	0	0
Magnetisation of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone-corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetisation of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0
Specific Volume of Liquids	25	0	0
Estimation of Potash and Phosphoric Acid	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations	100	0	0
Kent's Cavern Exploration	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record	100	0	0
Instructions for Travellers	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall	100	0	0
Ohm's Law	9	15	0
Tide Calculating Machine	200	0	0
Specific Volume of Liquids	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodacetoacetate	5	0	0
Estimation of Potash and Phosphoric Acid	13	0	0
Exploration of Victoria Cave	100	0	0
Geological Record	100	0	0
Kent's Cavern Exploration	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland	1	10	0
Zoological Record	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Naples Zoological Station	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles	13	15	0
Measuring Speed of Ships	10	0	0
Effect of Propeller on turning of Steam-vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acid in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpeæ, Report on	20	0	0
Mechanical Equivalent of Heat	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperature	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodacetoacetate	10	0	0
British Earthworks	25	0	0
Atmospheric Electricity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid	1	18	0
Geological Record	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c	15	0	0
	£1128	9	7

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1878.

	£	s.	d.
Exploration of Settle Caves	100	0	0
Geological Record	100	0	0
Investigation of Pulse Phenomena by means of Siphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters	15	0	0
Transmission of Electrical Impulses through Nerve Structure	30	0	0
Calculation of Factor Table for 4th Million	100	0	0
Anthropometric Committee	66	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0
Anthropometric Committee	50	0	0
Natural History of Socotra	100	0	0
Calculation of Factor Tables for 5th and 6th Millions	150	0	0
Underground Waters	10	0	0
Steering of Screw Steamers	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration	50	0	0
Geological Record	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

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1881.

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature ...	20	0	0
Electrical Standards	25	0	0
High Insulation Key.....	5	0	0
Tidal Observations	10	0	0
Specific Refractions	7	3	1
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station ...	50	0	0
Naples Zoological Station ...	75	0	0
Natural History of Socotra ...	50	0	0
Anthropological Notes and Queries	9	0	0
Zoological Record.....	100	0	0
Weights and Heights of Human Beings	30	0	0
	£476	3	1

1882.

Exploration of Central Africa	100	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Standards for Electrical Measurements	100	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements.....	50	0	0
Photographing Ultra-violet Spark Spectra	25	0	0
Geological Record.....	100	0	0
Earthquake Phenomena of Japan	25	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Fossil Plants of Halifax	15	0	0
Geological Map of Europe ...	25	0	0
Circulation of Underground Waters.....	15	0	0
Tertiary Flora of North of Ireland	20	0	0
British Polyzoa	10	0	0
Exploration of Caves of South of Ireland	10	0	0
Exploration of Raygill Fissure	20	0	0
Naples Zoological Station ...	80	0	0
Albuminoid Substances of Serum	10	0	0
Elimination of Nitrogen by Bodily Exercise.....	50	0	0
Migration of Birds	15	0	0
Natural History of Socotra...	100	0	0
Natural History of Timor-laut	100	0	0
Record of Zoological Literature	100	0	0
Anthropometric Committee...	50	0	0
	£1126	1	11

1883.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Isomeric Naphthalene Derivatives.....	15	0	0
Earthquake Phenomena of Japan	50	0	0
Fossil Plants of Halifax.....	20	0	0
British Fossil Polyzoa	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Circulation of Underground Waters.....	15	0	0
Geological Record.....	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Zoological Literature Record	100	0	0
Migration of Birds	20	0	0
Zoological Station at Naples	80	0	0
Scottish Zoological Station...	25	0	0
Elimination of Nitrogen by Bodily Exercise.....	38	3	3
Exploration of Mount Kilima-njaro..... .	500	0	0
Investigation of Loughton Camp	10	0	0
Natural History of Timor-laut	50	0	0
Screw Gauges.....	5	0	0
	£1083	3	3

1884.

Meteorological Observations on Ben Nevis	50	0	0
Collecting and Investigating Meteoric Dust.....	20	0	0
Meteorological Observatory at Chepstow.....	25	0	0
Tidal Observations.....	10	0	0
Ultra Violet Spark Spectra ...	8	4	0
Earthquake Phenomena of Japan	75	0	0
Fossil Plants of Halifax	15	0	0
Fossil Polyzoa.....	10	0	0
Erratic Blocks of England ...	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Circulation of Underground Waters.....	5	0	0
International Geological Map	20	0	0
Bibliography of Groups of Invertebrata	50	0	0
Natural History of Timor-laut	50	0	0
Naples Zoological Station ...	80	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Migration of Birds.....	20	0	0
Coagulation of Blood.....	100	0	0
Zoological Literature Record	100	0	0
Anthropometric Committee...	10	0	0
	£1173	4	0

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1885.

	£	s.	d.
Synoptic Chart of Indian Ocean	50	0	0
Reduction of Tidal Observations	10	0	0
Calculating Tables in Theory of Numbers	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Meteoric Dust	70	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions	20	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Raygill Fissure	15	0	0
Earthquake Phenomena of Japan	70	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Fossil Plants of British Tertiary and Secondary Beds	50	0	0
Geological Record	50	0	0
Circulation of Underground Waters	10	0	0
Naples Zoological Station	100	0	0
Zoological Literature Record	100	0	0
Migration of Birds	30	0	0
Exploration of Mount Kilimanjaro	25	0	0
Recent Polyzoa	10	0	0
Granton Biological Station	100	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Exploration of New Guinea	200	0	0
Exploration of Mount Roraima	100	0	0
	£1385	0	0

1886.

	£	s.	d.
Electrical Standards	40	0	0
Solar Radiation	9	10	6
Tidal Observations	50	0	0
Magnetic Observations	10	10	0
Observations on Ben Nevis	100	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
Chemical Nomenclature	5	0	0
Fossil Plants of British Tertiary and Secondary Beds	20	0	0
Caves in North Wales	25	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Geological Record	100	0	0
Palæozoic Phyllopoda	15	0	0
Zoological Literature Record	100	0	0
Granton Biological Station	75	0	0
Naples Zoological Station	50	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Migration of Birds	30	0	0
Secretion of Urine	10	0	0
Exploration of New Guinea	150	0	0
Regulation of Wages under Sliding Scales	10	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada	50	0	0
	£995	0	6

1887.

	£	s.	d.
Solar Radiation	18	10	0
Electrolysis	30	0	0
Ben Nevis Observatory	75	0	0
Standards of Light (1886 grant)	20	0	0
Standards of Light (1887 grant)	10	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Magnetic Observations	26	2	0
Electrical Standards	50	0	0
Silent Discharge of Electricity	20	0	0
Absorption Spectra	40	0	0
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Cae Gwyn Cave, N. Wales	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	20	0	0
Coal Plants of Halifax	25	0	0
Microscopic Structure of the Rocks of Anglesey	10	0	0
Exploration of the Eocene Beds of the Isle of Wight	20	0	0
Underground Waters	5	0	0
'Manure' Gravels of Wexford	10	0	0
Provincial Museums Reports	5	0	0
Lymphatic System	25	0	0
Naples Biological Station	100	0	0
Plymouth Biological Station	50	0	0
Granton Biological Station	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Flora and Fauna of the Cameroons	75	0	0
Migration of Birds	30	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Regulation of Wages	10	0	0
Prehistoric Race of Greek Islands	20	0	0
Racial Photographs, Egyptian	20	0	0
	£1186	18	0

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1888.

	£	s.	d.
Ben Nevis Observatory	150	0	0
Electrical Standards	2	6	4
Magnetic Observations	15	0	0
Standards of Light	79	2	3
Electrolysis	30	0	0
Uniform Nomenclature in Mechanics	10	0	0
Silent Discharge of Electricity	9	11	10
Properties of Solutions	25	0	0
Influence of Silicon on Steel	20	0	0
Methods of Teaching Chemistry	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Action of Light on Hydracids	20	0	0
Sea Beach near Bridlington	20	0	0
Geological Record	50	0	0
Manure Gravels of Wexford	10	0	0
Erosion of Sea Coasts	10	0	0
Underground Waters	5	0	0
Palæontographical Society	50	0	0
Pliocene Fauna of St. Erth	50	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Zoology and Botany of West Indies	100	0	0
Flora of Bahamas	100	0	0
Development of Fishes—St. Andrews	50	0	0
Marine Laboratory, Plymouth	100	0	0
Migration of Birds	30	0	0
Flora of China	75	0	0
Naples Zoological Station	100	0	0
Lymphatic System	25	0	0
Biological Station at Granton	50	0	0
Peradeniya Botanical Station	50	0	0
Development of Teleostei	15	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Effect of Occupations on Physical Development	25	0	0
North-Western Tribes of Canada	100	0	0
Prehistoric Race in Greek Islands	20	0	0
	£1511	0	5

1889.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	75	0	0
Electrolysis	20	0	0
Surface Water Temperature	30	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids	10	0	0
Geological Record	80	0	0
Volcanic Phenomena of Japan	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	20	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
West Indian Explorations	100	0	0
Flora of China	25	0	0
Naples Zoological Station	100	0	0
Physiology of Lymphatic System	25	0	0
Experiments with a Tow-net	5	16	3
Natural History of Friendly Islands	100	0	0
Geology and Geography of Atlas Range	100	0	0
Action of Waves and Currents in Estuaries	100	0	0
North-Western Tribes of Canada	150	0	0
Nomad Tribes of Asia Minor	30	0	0
Corresponding Societies	20	0	0
Marine Biological Association	200	0	0
'Baths Committee,' Bath	100	0	0
	£1417	0	11

1890.

	£	s.	d.
Electrical Standards	12	17	0
Electrolysis	5	0	0
Electro-optics	50	0	0
Mathematical Tables	25	0	0
Volcanic and Seismological Phenomena of Japan	75	0	0
Pellian Equation Tables	15	0	0
Properties of Solutions	10	0	0
International Standard for the Analysis of Iron and Steel	10	0	0
Influence of the Silent Discharge of Electricity on Oxygen	5	0	0
Methods of teaching Chemistry	10	0	0
Recording Results of Water Analysis	4	1	0
Oxidation of Hydracids in Sunlight	15	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	10	0	0
Circulation of Underground Waters	5	0	0
Excavations at Oldbury Hill	15	0	0
Cretaceous Polyzoa	10	0	0
Geological Photographs	7	14	11
Lias Beds of Northampton	25	0	0
Botanical Station at Peradeniya	25	0	0

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	£	s.	d.
Experiments with a Tow-net	4	3	9
Naples Zoological Station	100	0	0
Zoology and Botany of the West India Islands	100	0	0
Marine Biological Association	30	0	0
Action of Waves and Currents in Estuaries	150	0	0
Graphic Methods in Mechanical Science	11	0	0
Anthropometric Calculations	5	0	0
Nomad Tribes of Asia Minor	25	0	0
Corresponding Societies	20	0	0
	£799	16	8

1891.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	100	0	0
Electrolysis	5	0	0
Seismological Phenomena of Japan	10	0	0
Temperatures of Lakes	20	0	0
Photographs of Meteorological Phenomena	5	0	0
Discharge of Electricity from Points	10	0	0
Ultra Violet Rays of Solar Spectrum	50	0	0
International Standard for Analysis of Iron and Steel	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Formation of Haloids	25	0	0
Action of Light on Dyes	17	10	0
Geological Record	100	0	0
Volcanic Phenomena of Vesuvius	10	0	0
Fossil Phyllopoda	10	0	0
Photographs of Geological Interest	9	5	0
Lias of Northamptonshire	25	0	0
Registration of Type-Specimens of British Fossils	5	5	0
Investigation of Elbolton Cave	25	0	0
Botanical Station at Peradeniya	50	0	0
Experiments with a Tow-net	40	0	0
Marine Biological Association	12	10	0
Disappearance of Native Plants	5	0	0
Action of Waves and Currents in Estuaries	125	0	0
Anthropometric Calculations	10	0	0
New Edition of 'Anthropological Notes and Queries'	50	0	0
North-Western Tribes of Canada	200	0	0
Corresponding Societies	25	0	0
	£1,029	10	0

1892.

	£	s.	d.
Observations on Ben Nevis	50	0	0
Photographs of Meteorological Phenomena	15	0	0
Pellian Equation Tables	10	0	0
Discharge of Electricity from Points	50	0	0
Seismological Phenomena of Japan	10	0	0
Formation of Haloids	12	0	0
Properties of Solutions	10	0	0
Action of Light on Dyed Colours	10	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	20	0	0
Underground Waters	10	0	0
Investigation of Elbolton Cave	25	0	0
Excavations at Oldbury Hill	10	0	0
Cretaceous Polyzoa	10	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	17	10	0
Deep-sea Tow-net	40	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	100	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Anthropometric Laboratory	5	0	0
Anthropological Notes and Queries	20	0	0
Prehistoric Remains in Mashonaland	50	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	25	0	0
	£864	10	0

1893.

	£	s.	d.
Electrical Standards	25	0	0
Observations on Ben Nevis	150	0	0
Mathematical Tables	15	0	0
Intensity of Solar Radiation	2	8	6
Magnetic Work at the Falmouth Observatory	25	0	0
Isomeric Naphthalene Derivatives	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	5	0	0
Underground Waters	5	0	0
Shell-bearing Deposits at Clava, Chapelhall, &c.	20	0	0
Eurypterids of the Pentland Hills	10	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	30	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	50	0	0

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	£	s.	d.
Exploration of Irish Sea	30	0	0
Physiological Action of Oxygen in Asphyxia	20	0	0
Index of Genera and Species of Animals	20	0	0
Exploration of Karakoram Mountains	50	0	0
Scottish Place-names	7	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Economic Training	3	7	0
Anthropometric Laboratory	5	0	0
Exploration in Abyssinia	25	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	30	0	0
	£907	15	6

1894.

Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Tables of Mathematical Functions	15	0	0
Intensity of Solar Radiation	5	5	6
Wave-length Tables	10	0	0
Action of Light upon Dyed Colours	5	0	0
Erratic Blocks	15	0	0
Fossil Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	20	0	0
Eurypterids of the Pentland Hills	5	0	0
New Sections of Stonesfield Slate	14	0	0
Observations on Earth-tremors	50	0	0
Exploration of Calf-Hole Cave	5	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	5	0	0
Zoology of the Sandwich Islands	100	0	0
Zoology of the Irish Sea	40	0	0
Structure and Function of the Mammalian Heart	10	0	0
Exploration in Abyssinia	30	0	0
Economic Training	9	10	0
Anthropometric Laboratory Statistics	5	0	0
Ethnographical Survey	10	0	0
The Lake Village at Glastonbury	40	0	0
Anthropometrical Measurements in Schools	5	0	0
Mental and Physical Condition of Children	20	0	0
Corresponding Societies	25	0	0
	£583	15	6

1895.

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Earth Tremors	75	0	0
Abstracts of Physical Papers	100	0	0
Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
Comparison of Magnetic Standards	25	0	0
Meteorological Observations on Ben Nevis	50	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives	30	0	0
Electrolytic Quantitative Analysis	30	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut	50	0	0
Calibration and Comparison of Measuring Instruments	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies	30	0	0
	£977	15	5

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1896.

	£	s.	d.
Photographs of Meteorological Phenomena	15	0	0
Seismological Observations	80	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Uniformity of Size of Pages of Transactions, &c.	5	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	2	6	1
Electrolytic Quantitative Analysis	10	0	0
The Carbohydrates of Barley Straw	50	0	0
Reprinting Discussion on the Relation of Agriculture to Science	5	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	2	0	0
Investigation of a Coral Reef by Boring and Sounding	10	0	0
Examination of Locality where the Cetiosaurus in the Oxford Museum was found	25	0	0
Palæolithic Deposits at Hoxne	25	0	0
Fauna of Singapore Caves	40	0	0
Age and Relation of Rocks near Moreseat, Aberdeen	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	50	0	0
Zoology of the Sandwich Islands	100	0	0
African Lake Fauna	100	0	0
Oysters under Normal and Abnormal Environment	40	0	0
Climatology of Tropical Africa	10	0	0
Calibration and Comparison of Measuring Instruments	20	0	0
Small Screw Gauge	10	0	0
North-Western Tribes of Canada	100	0	0
Lake Village at Glastonbury	30	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies Committee	30	0	0
	£1,104	6	1

1897.

	£	s.	d.
Mathematical Tables	25	0	0
Seismological Observations	100	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electrochemistry	50	0	0
Electrolytic Quantitative Analysis	10	0	0
Isomeric Naphthalene Derivatives	50	0	0
Erratic Blocks	10	0	0
Photographs of Geological Interest	15	0	0
Remains of the Irish Elk in the Isle of Man	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	9	10	8
Zoological Bibliography and Publication	5	0	0
Index Generum et Specierum Animalium	100	0	0
Zoology and Botany of the West India Islands	40	0	0
The Details of Observations on the Migration of Birds	40	0	0
Climatology of Tropical Africa	20	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Silchester Excavation	20	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	180	0	0
Oysters and Typhoid	30	0	0
Physiological Applications of the Phonograph	15	0	0
Physiological Effects of Peptone and its Precursors	20	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Committee	25	0	0
	£1,059	10	8

1898.

	£	s.	d.
Electrical Standards	75	0	0
Seismological Observations	75	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electro-chemistry	35	0	0
Meteorological Observatory at Montreal	50	0	0

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	£	s.	d.
Wave-length Tables of the Spectra of the Elements ...	20	0	0
Action of Light upon Dyed Colours	8	0	0
Erratic Blocks	5	0	0
Investigation of a Coral Reef	40	0	0
Photographs of Geological Interest	10	0	0
Life-zones in British Carboniferous Rocks.....	15	0	0
Pleistocene Fauna and Flora in Canada	20	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	14	0	0
Index Generum et Specierum Animalium	100	0	0
Healthy and Unhealthy Oysters	30	0	0
Climatology of Tropical Africa	10	0	0
State Monopolies in other Countries	15	0	0
Small Screw Gauge	20	0	0
North-Western Tribes of Canada.....	75	0	0
Lake Village at Glastonbury	37	10	0
Silchester Excavation	7	10	0
Ethnological Survey of Canada	75	0	0
Anthropology and Natural History of Torres Straits...	125	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	100	0	0
Fertilisation in Phæophyceæ	15	0	0
Corresponding Societies Committee	25	0	0
	£1,212	0	0

1899.

Electrical Standards.....	225	0	0
Seismological Observations...	65	14	8
Science Abstracts	100	0	0
Heat of Combination of Metals in Alloys.....	20	0	0
Radiation in a Magnetic Field	50	0	0
Calculation of certain Integrals.....	10	0	0
Action of Light upon Dyed Colours	4	19	6
Relation between Absorption Spectra and Constitution of Organic Substances	50	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	10	0	0
Remains of Irish Elk in the Isle of Man.....	15	0	0
Pleistocene Flora and Fauna in Canada	30	0	0
Records of Disappearing Drift Section at Moel Tryfaen ...	5	0	0
Ty Newydd Caves.....	40	0	0
Ossiferous Caves at Uphill ...	30	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium.....	100	0	0
Migration of Birds	15	0	0
Apparatus for Keeping Aquatic Organisms under Definite Physical Conditions	15	0	0
Plankton and Physical Conditions of the English Channel during 1899.....	100	0	0
Exploration of Sokotra	35	0	0
Lake Village at Glastonbury	50	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	35	0	0
New Edition of 'Anthropological Notes and Queries'...	40	0	0
Age of Stone Circles.....	20	0	0
Physiological Effects of Peptone.....	30	0	0
Electrical Changes accompanying Discharge of Respiratory Centres.....	20	0	0
Influence of Drugs upon the Vascular Nervous System...	10	0	0
Histological Changes in Nerve Cells.....	20	0	0
Micro-chemistry of Cells	40	0	0
Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	10	0	0
Fertilisation in Phyæophyceæ	20	0	0
Assimilation in Plants.....	20	0	0
Zoological and Botanical Publication	5	0	0
Corresponding Societies Committee	25	0	0
	£1,430	14	2

1900.

Electrical Standards.....	25	0	0
Seismological Observations...	60	0	0
Radiation in a Magnetic Field	25	0	0
Meteorological Observatory at Montreal.....	20	0	0
Tables of Mathematical Functions	75	0	0
Relation between Absorption Spectra and Constitution of Organic Bodies.....	30	0	0
Wave-length Tables.....	5	0	0
Electrolytic Quantitative Analysis	5	0	0

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	£	s.	d.
Isomorphous Sulphonic Derivatives of Benzene	20	0	0
The Nature of Alloys	30	0	0
Photographs of Geological Interest	10	0	0
Remains of Elk in the Isle of Man	5	0	0
Pleistocene Fauna and Flora in Canada	10	0	0
Movements of Underground Waters of Craven	40	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	50	0	0
Migration of Birds	15	0	0
Plankton and Physical Conditions of the English Channel	40	0	0
Zoology of the Sandwich Islands	100	0	0
Coral Reefs of the Indian Region	30	0	0
Physical and Chemical Constants of Sea-Water	100	0	0
Future Dealings in Raw Produce	2	10	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	50	0	0
New Edition of 'Anthropological Notes and Queries'	40	0	0
Photographs of Anthropological Interest	10	0	0
Mental and Physical Condition of Children in Schools	5	0	0
Ethnography of the Malay Peninsula	25	0	0
Physiological Effects of Peptone	20	0	0
Comparative Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	5	0	0
Electrical Changes in Mammalian Nerves	20	0	0
Vascular Supply of Secreting Glands	10	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Com.	20	0	0
	£1,072	10	0

1901.

Electrical Standards	45	0	0
Seismological Observations	75	0	0
Wave-length Tables	4	14	0
Isomorphous Sulphonic Derivatives of Benzene	35	0	0
Life-zones in British Carboniferous Rocks	20	0	0
Underground Water of North-west Yorkshire	50	0	0
Exploration of Irish Caves	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	75	0	0
Migration of Birds	10	0	0
Terrestrial Surface Waves	5	0	0
Changes of Land-level in the Phlegræan Fields	50	0	0
Legislation regulating Women's Labour	15	0	0
Small Screw Gauge	45	0	0
Resistance of Road Vehicles to Traction	75	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	30	0	0
Anthropological Teaching	5	0	0
Exploration in Crete	145	0	0
Physiological Effects of Peptone	30	0	0
Chemistry of Bone Marrow	5	15	11
Suprarenal Capsules in the Rabbit	5	0	0
Fertilisation in Phæophyceæ	15	0	0
Morphology, Ecology, and Taxonomy of Podostemaceæ	20	0	0
Corresponding Societies Committee	15	0	0
	£920	9	11

1902.

Electrical Standards	40	0	0
Seismological Observations	35	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	80	0	0
Relation between Absorption Spectra and Organic Substances	20	0	0
Wave-length Tables	5	0	0
Life-zones in British Carboniferous Rocks	10	0	0
Exploration of Irish Caves	45	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Migration of Birds	15	0	0
Structure of Coral Reefs of Indian Ocean	50	0	0

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	£	s.	d.
Compound Ascidians of the Clyde Area	25	0	0
Terrestrial Surface Waves	15	0	0
Legislation regulating Women's Labour	30	0	0
Small Screw Gauge	20	0	0
Resistance of Road Vehicles to Traction	50	0	0
Ethnological Survey of Canada	15	0	0
Age of Stone Circles	30	0	0
Exploration in Crete	100	0	0
Anthropometric Investigation of Native Egyptian Soldiers	15	0	0
Excavations on the Roman Site at Gelligaer	5	0	0
Changes in Hæmoglobin	15	0	0
Work of Mammalian Heart under Influence of Drugs	20	0	0
Investigation of the Cyanophyceæ	10	0	0
Reciprocal Influence of Universities and Schools	5	0	0
Conditions of Health essential to carrying on Work in Schools	2	0	0
Corresponding Societies Com.	15	0	0
	£947	0	0

1903.

Electrical Standards	35	0	0
Seismological Observations	40	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	40	0	0
Study of Hydro-aromatic Substances	20	0	0
Erratic Blocks	10	0	0
Exploration of Irish Caves	40	0	0
Underground Waters of North-west Yorkshire	40	0	0
Life-zones in British Carboniferous Rocks	5	0	0
Geological Photographs	10	0	0
Table at the Zoological Station at Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Tidal Bore, Sea Waves, and Beaches	15	0	0
Scottish National Antarctic Expedition	50	0	0
Legislation affecting Women's Labour	25	0	0
Researches in Crete	100	0	0
Age of Stone Circles	3	13	2
Anthropometric Investigation	5	0	0
Anthropometry of the Todas and other Tribes of Southern India	50	0	0
The State of Solution of Proteids	20	0	0
Investigation of the Cyanophyceæ	25	0	0
Respiration of Plants	12	0	0
Conditions of Health essential for School Instruction	5	0	0
Corresponding Societies Com.	20	0	0
	£845	13	2

General Meetings.

On Wednesday, September 9, at 8.30 P.M., in the Opera House, Southport, Professor James Dewar, M.A., LL.D., D.Sc., F.R.S., resigned the office of President to Sir Norman Lockyer, K.C.B., LL.D., F.R.S., who took the Chair, and delivered an Address, for which see page 3.

On Thursday, September 10, at 8.30 P.M., a Soirée took place in the Town Hall.

On Friday, September 11, at 8.30 P.M., in the Cambridge Hall, Dr. R. Munro delivered a Discourse on 'Man as Artist and Sportsman in the Palæolithic Period.'

On Monday, September 14, at 8.30 P.M., in the Cambridge Hall, Dr. A. W. Rowe delivered a Discourse on 'The Old Chalk Sea, and some of its Teachings.'

On Tuesday, September 15, at 8.30 P.M., a Soirée took place at the Town Hall.

On Wednesday, September 16, at 2.30 P.M., in the Cambridge Hall, the concluding General Meeting took place, when the Proceedings of the General Committee and the Grants of Money for Scientific Purposes were explained to the Members.

The Meeting was then adjourned to Cambridge. [The Meeting is appointed to commence on Wednesday, August 17, 1904.]

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PRESIDENT'S ADDRESS.

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ADDRESS

BY

SIR NORMAN LOCKYER, K.C.B., LL.D., F.R.S.,
CORRESPONDANT DE L'INSTITUT DE FRANCE,

PRESIDENT.

The Influence of Brain-power on History.

MY first duty to-night is a sad one. I have to refer to a great loss which this nation and this Association have sustained. By the death of the great Englishman and great statesman who has just passed away we members of the British Association are deprived of one of the most illustrious of our Past-Presidents. We have to mourn the loss of an enthusiastic student of science. We recognise that as Prime Minister he was mindful of the interests of science, and that to him we owe a more general recognition on the part of the State of the value to the nation of the work of scientific men. On all these grounds you will join in the expression of respectful sympathy with Lord Salisbury's family in their great personal loss which your Council has embodied this morning in a resolution of condolence.

Last year, when this friend of science ceased to be Prime Minister, he was succeeded by another statesman who also has given many proofs of his devotion to philosophical studies, and has shown in many utterances that he has a clear understanding of the real place of science in modern civilisation. We, then, have good grounds for hoping that the improvement in the position of science in this country which we owe to the one will also be the care of his successor, who has honoured the Association by accepting the unanimous nomination of your Council to be your President next year, an acceptance which adds a new lustre to this Chair.

On this we may congratulate ourselves all the more because I think, although it is not generally recognised, that the century into which we have now well entered may be more momentous than any which has preceded it, and that the present history of the world is being so largely moulded by the influence of brain-power, which in these modern days has to do with natural as well as human forces and laws, that statesmen and

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politicians will have in the future to pay more regard to education and science as empire-builders and empire-guarders than they have paid in the past.

The nineteenth century will ever be known as the one in which the influences of science were first fully realised in civilised communities; the scientific progress was so gigantic that it seems rash to predict that any of its successors can be more important in the life of any nation.

Disraeli, in 1873, referring to the progress up to that year, spoke as follows: 'How much has happened in these fifty years—a period more remarkable than any, I will venture to say, in the annals of mankind. I am not thinking of the rise and fall of Empires, the change of dynasties, the establishment of Governments. I am thinking of those revolutions of science which have had much more effect than any political causes, which have changed the position and prospects of mankind more than all the conquests and all the codes and all the legislators that ever lived.'[1]

The progress of science, indeed, brings in many considerations which are momentous in relation to the life of any limited community—any one nation. One of these considerations to which attention is now being greatly drawn is that a relative decline in national wealth derived from industries must follow a relative neglect of scientific education.

It was the late Prince Consort who first emphasised this when he came here fresh from the University of Bonn. Hence the 'Prince Consort's Committee,' which led to the foundation of the College of Chemistry, and afterwards of the Science and Art Department. From that time to this the warnings of our men of science have become louder and more urgent in each succeeding year. But this is not all; the commercial output of one country in one century as compared with another is not alone in question; the acquirement of the scientific spirit and a knowledge and utilisation of the forces of Nature are very much further reaching in their effects on the progress and decline of nations than is generally imagined.

Britain in the middle of the last century was certainly the country which gained most by the advent of science, for she was then in full possession of those material gifts of Nature, coal and iron, the combined winning and utilisation of which, in the production of machinery and in other ways, soon made her the richest country in the world, the seat and throne of invention and manufacture, as Mr. Carnegie has called her. Being the great producers and exporters of all kinds of manufactured goods, we became eventually, with our iron ships, the great carriers, and hence the supremacy of our mercantile marine and our present command of the sea.

The most fundamental change wrought by the early applications of science was in relation to producing and carrying power. With the winning of mineral wealth and the production of machinery in other

[1] *Nature*, November 27, 1873, vol. ix. p. 71.

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countries, and cheap and rapid transit between nations, our superiority as depending upon our first use of vast material resources was reduced. Science, which is above all things cosmopolitan—planetary, not national—internationalises such resources at once. In every market of the world

> 'things of beauty, things of use,
> Which one fair planet can produce,
> Brought from under every star,'

were soon to be found.

Hence the first great effect of the general progress of science was relatively to diminish the initial supremacy of Britain due to the first use of *material* resources, which indeed was the real source of our national wealth and place among the nations.

The unfortunate thing was that, while the foundations of our superiority depending upon our *material resources* were being thus sapped by a cause *which was beyond our control*, our statesmen and our Universities were blind leaders of the blind, and our other asset, our mental resources, which was within our control, was culpably neglected.

So little did the bulk of our statesmen know of the part science was playing in the modern world and of the real basis of the nation's activities that they imagined political and fiscal problems to be the only matters of importance. Nor, indeed, are we very much better off to-day. In the important discussions recently raised by Mr. Chamberlain next to nothing has been said of the effect of the progress of science on prices. The whole course of the modern world is attributed to the presence or absence of taxes on certain commodities in certain countries. The fact that the great fall in the price of food-stuffs in England did not come till some thirty or forty years after the removal of the corn duty between 1847 and 1849 gives them no pause; for them new inventions, railways, and steamships are negligible quantities; the vast increase in the world's wealth, in Free Trade and Protected countries alike, comes merely, according to them, in response to some *political* shibboleth.

We now know, from what has occurred in other States, that if our Ministers had been more wise and our Universities more numerous and efficient our *mental resources* would have been developed by improvements in educational method, by the introduction of science into schools, and, more important than all the rest, by the teaching of science by experiment, observation, and research, and not from books. It is because this was not done that we have fallen behind other nations in properly applying science to industry, so that our applications of science to industry are relatively less important than they were. But this is by no means all; we have lacked the strengthening of the national life produced by fostering the scientific spirit among all classes and along all lines of the nation's activity; many of the responsible authorities know little and care less about science; we have not learned that it is the duty of a State to organise its forces as carefully for peace as for war; that Universities and

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other teaching centres are as important as battleships or big battalions; are, in fact, essential parts of a modern State's machinery, and, as such, to be equally aided and as efficiently organised to secure its future well-being.

Now the objects of the British Association as laid down by its founders seventy-two years ago are 'To give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers—to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress.'

In the main, my predecessors in this Chair, to which you have done me the honour to call me, have dealt, and with great benefit to science, with the objects first named.

But at a critical time like the present I find it imperative to depart from the course so generally followed by my predecessors and to deal with the last object named, for unless by some means or other we 'obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress,' we shall suffer in competition with other communities in which science is more generally utilised for the purposes of the national life.

The Struggle for Existence in Modern Communities.

Some years ago, in discussing the relations of scientific instruction to our industries, Huxley pointed out that we were in presence of a new 'struggle for existence,' a struggle which, once commenced, must go on until only the fittest survives.

It is a struggle between organised species—nations—not between individuals or any class of individuals. It is, moreover, a struggle in which science and brains take the place of swords and sinews, on which depended the result of those conflicts which, up to the present, have determined the history and fate of nations. The school, the University, the laboratory, and the workshop are the battlefields of this new warfare.

But it is evident that if this, or anything like it, be true, our industries cannot be involved alone; the scientific spirit, brain-power, must not be limited to the workshop, if other nations utilise it in all branches of their administration and executive.

It is a question of an important change of front. It is a question of finding a new basis of stability for the Empire in face of new conditions. I am certain that those familiar with the present state of things will acknowledge that the Prince of Wales's call, 'Wake up,' applies quite as much to the members of the Government as it does to the leaders of industry.

What is wanted is a complete organisation of the resources of the nation, so as to enable it best to face all the new problems which the

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progress of science, combined with the ebb and flow of population and other factors in international competition, are ever bringing before us. Every Minister, every public department, is involved; and this being so, it is the duty of the whole nation—King, Lords, and Commons—to do what is necessary to place our scientific institutions on a proper footing in order to enable us to 'face the music,' whatever the future may bring. The idea that science is useful only to our industries comes from want of thought. If anyone is under the impression that Britain is only suffering at present from the want of the scientific spirit among our industrial classes, and that those employed in the State service possess adequate brain-power and grip of the conditions of the modern world into which science so largely enters, let him read the Report of the Royal Commission on the War in South Africa. There he will see how the whole 'system' employed was, in Sir Henry Brackenbury's words applied to a part of it, '*unsuited to the requirements of an army which is maintained to enable us to make war.*' Let him read also in the Address of the President of the Society of Chemical Industry what drastic steps had to be taken by Chambers of Commerce and 'a quarter of a million of working-men' to get the Patent Law Amendment Act into proper shape in spite of all the advisers and officials of the Board of Trade. Very few people realise the immense number of scientific problems the solution of which is required for the State service. The nation itself is a gigantic workshop; and the more our rulers and legislators, administrators and executive officers possess the scientific spirit, the more the rule of thumb is replaced in the State service by scientific methods, the more able shall we be, thus armed at all points, to compete successfully with other countries along all lines of national as well as of commercial activity.

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in the peace struggles to which I have referred is another. In the latter the source and standard of national efficiency are entirely changed. To meet war conditions, there must be equality or superiority in battleships and army corps. To meet the new peace conditions, there must be equality or superiority in Universities, scientific organisation, and everything which conduces to greater brain-power.

Our Industries are suffering in the present International Competition.

The present condition of the nation, so far as its industries are concerned, is as well known, not only to the Prime Minister, but to other political leaders in and out of the Cabinet, as it is to you and to me. Let me refer to two speeches delivered by Lord Rosebery and Mr. Chamberlain on two successive days in January 1901.

Lord Rosebery spoke as follows:—

'. . . The war I regard with apprehension is the war of trade which is unmistakably upon us. . . . When I look round me I cannot blind my

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eyes to the fact that, so far as we can predict anything of the twentieth century on which we have now entered, it is that it will be one of acutest international conflict in point of trade. We were the first nation of the modern world to discover that trade was an absolute necessity. For that we were nicknamed a nation of shopkeepers; but now every nation wishes to be a nation of shopkeepers too, and I am bound to say that when we look at the character of some of these nations, and when we look at the intelligence of their preparations, we may well feel that it behoves us not to fear, but to gird up our loins in preparation for what is before us.'

Mr. Chamberlain's views were stated in the following words:—

'I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the existence of this country, as the great commercial nation, depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals.'

All this refers to our industries. We are suffering because trade no longer follows the flag as in the old days, but because trade follows the brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany 400 doctors of science, the best the Universities there can turn out, have been employed at different times in late years. In the United States the most successful students in the higher teaching centres are snapped up the moment they have finished their course of training, and put into charge of large concerns, so that the idea has got abroad that youth is the password of success in American industry. It has been forgotten that the latest product of the highest scientific education must necessarily be young, and that it is the training and not the age which determines his employment. In Britain, on the other hand, apprentices who can pay high premiums are too often preferred to those who are well educated, and the old rule-of-thumb processes are preferred to new developments—a conservatism too often depending upon the master's own want of knowledge.

I should not be doing my duty if I did not point out that the defeat of our industries one after another, concerning which both Lord Rosebery and Mr. Chamberlain express their anxiety, is by no means the only thing we have to consider. The matter is not one which concerns our industrial classes only, for knowledge must be pursued for its own sake; and since the full life of a nation with a constantly increasing complexity, not only of industrial, but of high national aims, depends upon the universal presence of the scientific spirit—in other words, brain-power—our whole national life is involved.

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The Necessity for a Body dealing with the Organisation of Science.

The present awakening in relation to the nation's real needs is largely due to the warnings of men of science. But Mr. Balfour's terrible Manchester picture of our present educational condition [1] shows that the warning, which has been going on now for more than fifty years, has not been forcible enough; but if my contention that other reorganisations besides that of our education are needed is well founded, and if men of science are to act the part of good citizens in taking their share in endeavouring to bring about a better state of things, the question arises, Has the neglect of their warnings so far been due to the way in which these have been given?

Lord Rosebery, in the address to a Chamber of Commerce from which I have already quoted, expressed his opinion that such bodies do not exercise so much influence as might be expected of them. But if commercial men do not use all the power their organisation provides, do they not by having built up such an organisation put us students of science to shame, who are still the most disorganised members of the community?

Here, in my opinion, we have the real reason why the scientific needs of the nation fail to command the attention either of the public or of successive Governments. At present, appeals on this or on that behalf are the appeals of individuals; science has no collective voice on the larger national questions; there is no organised body which formulates her demands.

During many years it has been part of my duty to consider such matters, and I have been driven to the conclusion that our great crying need is to bring about an organisation of men of science and all interested in science similar to those which prove so effective in other branches of human activity. For the last few years I have dreamt of a Chamber, Guild, League, call it what you will, with a wide and large membership, which should give us what, in my opinion, is so urgently needed. Quite recently I sketched out such an organisation, but what was my astonishment to find that I had been forestalled, and by the founders of the British Association!

The British Association such a Body.

At the commencement of this Address I pointed out that one of the objects of the Association, as stated by its founders, was 'to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress.'

Everyone connected with the British Association from its beginning

[1] 'The existing educational system of this country is chaotic, is ineffectual, is utterly behind the age, makes us the laughing-stock of every advanced nation in Europe and America, puts us behind, not only our American cousins, but the German and the Frenchman and the Italian.'—*Times*, October 15, 1902.

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may be congratulated upon the magnificent way in which the other objects of the Association have been carried out; but as one familiar with the Association for the last forty years I cannot but think that the object to which I have specially referred has been too much overshadowed by the work done in connection with the others.

A careful study of the early history of the Association leads me to the belief that the function I am now dwelling on was strongly in the minds of the founders; but be this as it may, let me point out how admirably the organisation is framed to enable men of science to influence public opinion and so to bring pressure to bear upon Governments which follow public opinion. (1) Unlike all the other chief metropolitan societies, its outlook is not limited to any branch or branches of science. (2) We have a wide and numerous fellowship, including both the leaders and the lovers of science, in which all branches of science are and always have been included with the utmost catholicity—a condition which renders strong committees possible on any subject. (3) An annual meeting at a time when people can pay attention to the deliberations, and when the newspapers can print reports. (4) The possibility of beating up recruits and establishing local committees in different localities, even in the King's dominions beyond the seas, since the place of meeting changes from year to year, and is not limited to these islands.

We not only, then, have a scientific Parliament competent to deal with all matters, including those of national importance, relating to science, but machinery for influencing all new councils and committees dealing with local matters, the functions of which are daily becoming more important.

The machinery might consist of our corresponding societies. We already have affiliated to us seventy societies with a membership of 25,000. Were this number increased so as to include every scientific society in the Empire, metropolitan and provincial, we might eventually hope for a membership of half a million.

I am glad to know that the Council is fully alive to the importance of giving a greater impetus to the work of the corresponding societies. During this year a committee was appointed to deal with the question; and later still, after this committee had reported, a conference was held between this committee and the corresponding societies committee to consider the suggestions made, some of which will be gathered from the following extract:—

'In view of the increasing importance of science to the nation at large, your committee desire to call the attention of the Council to the fact that in the corresponding societies the British Association has gathered in the various centres represented by these societies practically all the scientific activity of the provinces. The number of members and associates at present on the list of the corresponding societies approaches 25,000, and no organisation is in existence anywhere in the country better adapted

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than the British Association for stimulating, encouraging, and co-ordinating all the work being carried on by the seventy societies at present enrolled, Your committee are of opinion that further encouragement should be given to these societies and their individual working members by every means within the power of the Association; and with the object of keeping the corresponding societies in more permanent touch with the Association they suggest that an official invitation on behalf of the Council be addressed to the societies, through the corresponding societies committee, asking them to appoint standing British Association sub-committees, to be elected by themselves, with the object of dealing with all those subjects of investigation common to their societies and to the British Association committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres. . . .

'Your committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the corresponding societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the corresponding societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the Education Committees now being appointed under the new Act. The educational section of the Association having been but recently added, the corresponding societies have as yet not had much opportunity for taking part in this branch of the Association's work; and in view of the reorganisation in education now going on all over the country your committee are of opinion that no more opportune time is likely to occur for the influence of scientific organisations to make itself felt as a real factor in national education. . . .'

I believe that if these suggestions or anything like them—for some better way may be found on inquiry—are accepted, great good to science throughout the Empire will come. Rest assured that sooner or later such a Guild will be formed because it is needed. It is for you to say whether it shall be, or form part of, the British Association. We in this Empire certainly need to organise science as much as in Germany they find the need to organise a navy. The German Navy League, which has branches even in our Colonies, already has a membership of 630,000, and its income is nearly 20,000*l.* a year. A British Science League of 500,000 with a sixpenny subscription would give us 12,000*l.* a year, quite enough to begin with.

I for one believe that the British Association would be a vast gainer by such an expansion of one of its existing functions. Increased authority and prestige would follow its increased utility. The meetings would possess a new interest; there would be new subjects for reports; missionary work less needed than formerly would be replaced by efforts much more suited to the real wants of the time. This magnificent, strong, and complicated organisation would become a living force, working throughout the

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year instead of practically lying idle, useless, and rusting for fifty-one weeks out of the fifty-two so far as its close association with its members is concerned.

If this suggestion in any way commends itself to you, then when you begin your work in your sections or General Committee see to it that a body is appointed to inquire how the thing can be done. Remember that the British Association will be as much weakened by the creation of a new body to do the work I have shown to have been in the minds of its founders as I believe it will be strengthened by becoming completely effective in every one of the directions they indicated, and for which effectiveness we, their successors, are indeed responsible. The time is appropriate for such a reinforcement of one of the wings of our organisation, for we have recently included Education among our sections.

There is another matter I should like to see referred to the committee I have spoken of, if it please you to appoint it. The British Association—which, as I have already pointed out, is now the chief body in the Empire which deals with the totality of science—is, I believe, the only organisation of any consequence which is without a charter, and which has not his Majesty the King as patron.

The First Work of such an Organisation.

I suppose it is my duty, after I have suggested the need of organisation, to tell you my personal opinion as to the matters where we suffer most in consequence of our lack of organisation at the present time.

Our position as a nation, our success as merchants, are in peril chiefly—dealing with preventable causes—because of our lack of completely efficient Universities and our neglect of research. This research has a double end. A professor who is not learning cannot teach properly or arouse enthusiasm in his students; while a student of anything who is unfamiliar with research methods, and without that training which research brings, will not be in the best position to apply his knowledge in after-life. From neglect of research comes imperfect education and a small output of new applications and new knowledge to reinvigorate our industries. From imperfect education comes the unconcern touching scientific matters and the too frequent absence of the scientific spirit in the nation generally, from the Court to the Parish Council.

I propose to deal as briefly as I can with each of these points.

Universities.

I have shown that, so far as our industries are concerned, the cause of our failure has been run to earth; it is fully recognised that it arises from the insufficiency of our Universities both in numbers and efficiency, so that not only our captains of industry, but those employed in the nation's work generally, do not secure a training similar to that afforded by other nations. No additional endowment of primary, secondary, or

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technical instruction will mend matters. This is not merely the opinion of men of science; our great towns know it, our Ministers know it.

It is sufficient for me to quote Mr. Chamberlain :—

'It is not everyone who can, by any possibility, go forward into the higher spheres of education; but it is from those who do that we have to look for the men who in the future will carry high the flag of this country in commercial, scientific, and economic competition with other nations. At the present moment I believe there is nothing more important than to supply the deficiencies which separate us from those with whom we are in the closest competition. In Germany, in America, in our own colony of Canada, and in Australia, the higher education of the people has more support from the Government, is carried further, than it is here in the Old Country; and the result is that in every profession, in every industry, you find the places taken by men and by women who have had a University education. And I would like to see the time in this country when no man should have a chance for any occupation of the better kind, either in our factories, our workshops, or our counting-houses, who could not show proof that in the course of his University career he had deserved the position that was offered to him. What is it that makes a country? Of course you may say, and you would be quite right, "The general qualities of the people, their resolution, their intelligence, their pertinacity, and many other good qualities." Yes; but that is not all, and it is not the main creative feature of a great nation. The greatness of a nation is made by its greatest men. It is those we want to educate. It is to those who are able to go, it may be, from the very lowest steps in the ladder, to men who are able to devote their time to higher education, that we have to look to continue the position which we now occupy as at all events one of the greatest nations on the face of the earth. And, feeling as I do on these subjects, you will not be surprised if I say that I think the time is coming when Governments will give more attention to this matter, and perhaps find a little more money to forward its interests.'[1]

Our conception of a University has changed. University education is no longer regarded as the luxury of the rich, which concerns only those who can afford to pay heavily for it. The Prime Minister in a recent speech, while properly pointing out that the collective effect of our public and secondary schools upon British character cannot be overrated, frankly acknowledged that the boys of seventeen or eighteen who have to be educated in them 'do not care a farthing about the world they live in except in so far as it concerns the cricket-field or the football-field or the river.' On this ground they are not to be taught science; and hence, when they proceed to the University, their curriculum is limited to subjects which were better taught before the modern world existed, or even Galileo

[1] *Times*, November 6, 1902.

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was born. But the science which these young gentlemen neglect, with the full approval of their teachers, on their way through the school and the University to politics, the Civil Service, or the management of commercial concerns, is now one of the great necessities of a nation ; and our Universities must become as much the insurers of the future progress as battleships are the insurers of the present power of States. In other words, University competition between States is now as potent as competition in building battleships ; and it is on this ground that our University conditions become of the highest national concern, and therefore have to be referred to here, and all the more because our industries are not alone in question.

Why we have not more Universities.

Chief among the causes which have brought us to the terrible condition of inferiority as compared with other nations in which we find ourselves are our carelessness in the matter of education and our false notions of the limitations of State functions in relation to the conditions of modern civilisation.

Time was when the Navy was largely a matter of private and local effort. William the Conqueror gave privileges to the Cinque Ports on the condition that they furnished fifty-two ships when wanted. In the time of Edward III., of 730 sail engaged in the siege of Calais 705 were 'people's ships.' All this has passed away ; for our first line of defence we no longer depend on private and local effort.

Time was when not a penny was spent by the State on elementary education. Again, we no longer depend upon private and local effort. The Navy and primary education are now recognised as properly calling upon the public for the necessary financial support. But when we pass from primary to University education, instead of State endowment we find State neglect ; we are in a region where it is nobody's business to see that anything is done.

We in Great Britain have thirteen Universities competing with 134 State and privately endowed in the United States and twenty-two State-endowed in Germany. I leave other countries out of consideration for lack of time, and I omit all reference to higher institutions for technical training, of which Germany alone possesses nine of University rank, because they are less important ; they instruct rather than educate, and our want is education. The German State gives to one University more than the British Government allows to all the Universities and University Colleges in England, Ireland, Scotland, and Wales put together. These are the conditions which regulate the production of brain-power in the United States, Germany, and Britain respectively, and the excuse of the Government is that this is a matter for private effort. Do not our Ministers of State know that other civilised countries grant efficient State aid, and, further, that private effort has provided in Great Britain less than 10 per cent. of the sum thus furnished in the United States in

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addition to State aid? Are they content that we should go under in the great struggle of the modern world because the Ministries of other States are wiser, and because the individual citizens of another country are more generous, than our own?

If we grant that there was some excuse for the State's neglect so long as the higher teaching dealt only with words, and books alone had to be provided (for the streets of London and Paris have been used as class-rooms at a pinch), it must not be forgotten that during the last hundred years not only has knowledge been enormously increased, but things have replaced words, and fully equipped laboratories must take the place of books and class-rooms if University training worthy of the name is to be provided. There is much more difference in size and kind between an old and a new University than there is between the old caravel and a modern battleship, and the endowments must follow suit.

What are the facts relating to private endowment in this country? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in our country upon this form of endowment we are trusting to a broken reed. If we take the twelve English University Colleges, the forerunners of Universities unless we are to perish from lack of knowledge, we find that private effort during sixty years has found less than 4,000,000*l.*; that is, 2,000,000*l.* for buildings, and 40,000*l.* a year income. This gives us an average of 166,000*l.* for buildings, and 3,300*l.* for yearly income.

What is the scale of private effort we have to compete with in regard to the American Universities?

In the United States, during the last few years, Universities and colleges have received more than 40,000,000*l.* from this source alone; private effort supplied nearly 7,000,000*l.* in the years 1898–1900.

Next consider the amount of State aid to Universities afforded in Germany. The buildings of the new University of Strassburg have already cost nearly a million; that is, about as much as has yet been found by private effort for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle, and Sheffield. The Government annual endowment of the same German University is more than 49,000*l.*

This is what private endowment does for us in England, against State endowment in Germany.

But the State does really concede the principle; its present contribution to our Universities and colleges amounts to 155,600*l.* a year. No capital sum, however, is taken for buildings. The State endowment of the University of Berlin in 1891–92 amounted to 168,777*l.*

When, then, we consider the large endowments of University education both in the United States and Germany, it is obvious that State aid only can make any valid competition possible with either. The more we study the facts, the more statistics are gone into, the more do we find that we, to a large extent, lack both of the sources of endowment upon one or other, or both, of which other nations depend. We are between

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two stools, and the prospect is hopeless without some drastic changes. And first among these, if we intend to get out of the present Slough of Despond, must be the giving up of the idea of relying upon private effort.

That we lose most where the State does least is known to Mr. Chamberlain, for in his speech, to which I have referred, on the University of Birmingham, he said: 'As the importance of the aim we are pursuing becomes more and more impressed upon the minds of the people, we may find that we shall be more generously treated by the State.'

Later still, on the occasion of a visit to University College School, Mr. Chamberlain spoke as follows:—

'When we are spending, as we are, many millions—I think it is 13,000,000*l.*—a year on primary education, it certainly seems as if we might add a little more, even a few tens of thousands, to what we give to University and secondary education.'[1]

To compete on equal grounds with other nations we must have more Universities. But this is not all—we want a far better endowment of all the existing ones, not forgetting better opportunities for research on the part of both professors and students. Another crying need is that of more professors and better pay. Another is the reduction of fees; they should be reduced to the level existing in those countries which are competing with us—to, say, one-fifth of their present rates, so as to enable more students in the secondary and technical schools to complete their education.

In all these ways facilities would be afforded for providing the highest instruction to a much greater number of students. At present there are almost as many *professors and instructors* in the Universities and colleges of the United States as there are *day students* in the Universities and colleges of the United Kingdom.

Men of science, our leaders of industry, and the chiefs of our political parties all agree that our present want of higher education—in other words, properly equipped Universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain-power, which is leading to a relatively reduced national income.

The facts show that in this country we cannot depend upon private effort to put matters right. How about local effort?

Anyone who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and upkeep of Universities.

The buildings of the most modern University in Germany have cost a million. For upkeep the yearly sums found, chiefly by the State, for

[1] *Times*, November 6, 1902.

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German Universities of different grades, taking the incomes of seven out of the twenty-two Universities as examples, are :—

		£
First Class . . .	Berlin	130,000
Second Class. . .	Bonn Göttingen	56,000
Third Class . . .	Königsberg Strassburg	48,000
Fourth Class. . .	Heidelberg Marburg	37,000

Thus, if Leeds, which is to have a University, is content with the fourth class German standard, a rate must be levied of 7*d.* in the pound for yearly expenses, independent of all buildings. But the facts are that our towns are already at the breaking strain. During the last fifty years, in spite of enormous increases in rateable values, the rates have gone up from about 2*s.* to about 7*s.* in the pound for real *local* purposes. But no University can be a merely local institution.

How to get more Universities.

What, then, is to be done? Fortunately, we have a precedent admirably in point, the consideration of which may help us to answer this question.

I have pointed out that in old days our Navy was chiefly provided by local and private effort. Fortunately for us those days have passed away; but some twenty years ago, in spite of a large expenditure, it began to be felt by those who knew, that in consequence of the increase of foreign navies our sea power was threatened, as now, in consequence of the increase of foreign Universities, our brain-power is threatened.

The nation slowly woke up to find that its enormous commerce was no longer insured at sea, that in relation to foreign navies our own had been suffered to dwindle to such an extent that it was no longer capable of doing the duty which the nation expected of it even in times of peace. At first this revelation was received with a shrug of incredulity, and the peace-at-any-price party denied that anything was needed; but a great teacher arose;[1] as the facts were inquired into, the suspicion changed into an alarm; men of all parties saw that something must be done. Later the nation was thoroughly aroused, and with an universal agreement the principle was laid down that, cost what it might to enforce our sea-power, our Navy must be made and maintained of a strength greater than those of any two possibly contending Powers. After establishing this principle, the next thing to do was to give effect to it. What did the nation do after full discussion and inquiry? A Bill was brought in in 1888, and a sum of 21,500,000*l.* was voted in order, during the next five years, to inaugurate a large ship-building programme,

[1] Captain Mahan, of the U.S. Navy, whose book, 'On the Influence of Sea-power on History,' has suggested the title of my address.

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so that Britain and Britain's commerce might be guarded on the high seas in any event.

Since then we have spent 120,000,000*l.* on new ships, and this year we spend still more millions on still more new ships. If these prove insufficient to safeguard our sea-power, there is no doubt that the nation will increase them, and I have not heard that anybody has suggested an appeal to private effort.

How, then, do we stand with regard to Universities, recognising them as the chief producers of brain-power and therefore the equivalents of battleships in relation to sea-power? Do their numbers come up to the standard established by the Admiralty principle to which I have referred? Let us attempt to get a rough-and-ready estimate of our educational position by counting Universities as the Admiralty counts battleships. I say rough-and-ready, because we have other helps to greater brain-power to consider besides Universities, as the Admiralty has other ships to consider besides ironclads.

In the first place, let us inquire if they are equal in number to those of any two nations commercially competing with us.

In the United Kingdom we had until quite recently thirteen.[1] Of these, one is only three years old as a teaching University, and another is still merely an examining board.

In Germany there are twenty-two Universities; in France, under recent legislation, fifteen; in Italy, twenty-one. It is difficult to give the number in the United States, because it is clear, from the tables given in the Report of the Commissioner of Education, that some colleges are more important than some Universities, and both give the degree of Ph.D. But of Universities in title we have 134. Among these, there are forty-six with more than fifty professors and instructors, and thirteen with more than 150. I will take that figure.

Suppose we consider the United States and Germany, our chief commercial competitors, and apply the Admiralty principle. We should require, allowing for population, eight additional Universities at the very lowest estimate.

We see, then, that instead of having Universities equalling in number those of two of our chief competitors together, they are by no means equal to those of either of them singly.

After this statement of the facts, anyone who has belief in the importance of higher education will have no difficulty in understanding the origin of the present condition of British industry and its constant decline, first in one direction and then in another, since the tremendous efforts made in the United States and Germany began to take effect.

If, indeed, there be anything wrong about the comparison, the error can only arise from one of two sources—either the Admiralty is thought-

[1] These are Oxford, Cambridge, Durham, Victoria, Wales, Birmingham, London, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin, and Royal University.

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lessly and wastefully spending money, or there is no connection whatever between the higher intelligence and the prosperity of a nation. I have already referred to the views of Mr. Chamberlain and Lord Rosebery on this point; we know what Mr. Chamberlain has done at Birmingham; we know the strenuous efforts made by the commercial leaders of Manchester and Liverpool; we know, also, the opinion of men of science.

If while we spend so freely to maintain our sea-power our export of manufactured articles is relatively reduced because our competitors beat us in the markets of the world, what is the end of the vista thus opened up to us? A Navy growing stronger every year and requiring larger votes to guard our commerce and communications, and a vanishing quantity of commerce to guard—a reduced national income to meet an increasing taxation!

The pity is that our Government has considered sea-power alone; that while so completely guarding our commerce it has given no thought to one of the main conditions on which its production and increase depend. A glance could have shown that other countries were building Universities even faster than they were building battleships; were, in fact, considering brain-power first and sea-power afterwards.

Surely it is my duty as your President to point out the danger ahead, if such ignoring of the true situation should be allowed to continue. May I express a hope that at last, in Mr. Chamberlain's words, 'The time is coming when Governments will give more attention to this matter'?

What will they cost?

The comparison shows that we want eight new Universities, some of which, of course, will be colleges promoted to University rank and fitted to carry on University work. Three of them are already named: Manchester, Liverpool, Leeds.

Let us take this number and deal with it on the battleship condition, although a modern University on American or German models will cost more to build than a battleship.

If our present University shortage be dealt with on battleship conditions, to correct it we should expend *at least* 8,000,000*l.* for new construction, and for the pay-sheet we should have to provide ($8 \times 50{,}000l.$) 400,000*l.* yearly for *personnel* and up-keep; for it is of no use to build either ships or Universities without manning them. Let us say, roughly, capitalising the yearly payment at 2½ per cent., 24,000,000*l.*

At this stage it is important to inquire whether this sum, arrived at by analogy merely, has any relation to our real University needs.

I have spent a year in making inquiries, as full as I could make them, of friends conversant with the real present needs of each of the Universities, old and new. I have obtained statistics which would fill a volume, and personally I believe that this sum at least is required to bring our

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University system up to anything like the level which is insisted upon both in the United States and in Germany. Even Oxford, our oldest University, will still continue to be a mere bundle of colleges unless three millions are provided to enable the University, properly so called, to take her place among her sisters of the modern world; and Sir Oliver Lodge, the Principal of our very youngest University, Birmingham, has shown in detail how five millions can be usefully and properly applied in that one locality to utilise for the good of the nation the enthusiasm and scientific capacity which are only waiting for adequate opportunity of development.

How is this money to be raised? I reply, without hesitation, *Duplicate the Navy Bill of* 1888–9; do at once for brain-power what we so successfully did then for sea-power.

Let 24,000,000*l.* be set apart from one asset, our national wealth, to increase the other, brain-power. Let it be assigned and borrowed as it is wanted; there will be a capital sum for new buildings to be erected in the next five or ten years, the interest of the remainder to go towards increased annual endowments.

There need be no difficulty about allocating money to the various institutions. Let each University make up its mind as to which rank of the German Universities it wishes to emulate. When this claim has been agreed to, the sums necessary to provide the buildings and teaching staff of that class of University should be granted without demur.

It is the case of battleships over again, and money need not be spent more freely in one case than in the other.

Let me at once say that this sum is not to be regarded as practically gone when spent, as in the case of a short-lived ironclad. *It is a loan* which will bear a high rate of interest. This is not my opinion merely; it is the opinion of those concerned in great industrial enterprises and fully alive to the origin and effects of the present condition of things.

I have been careful to point out that the statement that our industries are suffering from our relative neglect of science does not rest on my authority. But if this be true, then if our annual production is less by only two millions than it might have been, having two millions less to divide would be equivalent to our having forty or fifty millions less capital than we should have had if we had been more scientific.

Sir John Brunner, in a speech connected with the Liverpool School of Tropical Medicine, stated recently that if we as a nation were now to borrow ten millions of money in order to help science by putting up buildings and endowing professors, we should get the money back in the course of a generation a hundredfold. He added that there was no better investment for a business man than the encouragement of science, and that every penny he possessed had come from the application of science to commerce.

According to Sir Robert Giffen, the United Kingdom as a going concern was in 1901 worth 16,000,000,000*l.*

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Were we to put aside 24,000,000*l.* for gradually organising, building, and endowing new Universities, and making the existing ones more efficient, we should still be worth 15,976,000,000*l.*—a property well worth defending by all the means, and chief among these brain-power, we can command.

If it be held that this, or anything like it, is too great a price to pay for correcting past carelessness or stupidity, the reply is that the 120,000,000*l.* recently spent on the Navy, a sum five times greater, has been spent to correct a sleepy blunder, not one whit more inimical to the future welfare of our country than that which has brought about our present educational position. We had not sufficiently recognised what other nations had done in the way of ship-building, just as until now we have not recognised what they have been doing in University building.

Further, I am told that the sum of 24,000,000*l.* is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries, owing to our lack of scientific training. Many other industries have been attacked in the same way since ; but taking this one instance alone, if we had spent this money fifty years ago, when the Prince Consort first called attention to our backwardness, the nation would now be much richer than it is, and would have much less to fear from competition.

Suppose we were to set about putting our educational house in order, so as to secure a higher quality and greater quantity of brain-power, it would not be the first time in history that this has been done. Both Prussia after Jena and France after Sedan acted on the view :—

> 'When land is gone and money spent,
> Then learning is most excellent.'

After Jena, which left Prussia a 'bleeding and lacerated mass,' the King and his wise counsellors, among them men who had gained knowledge from Kant, determined, as they put it, 'to supply the loss of territory by intellectual effort.'

What did they do? In spite of universal poverty, three Universities, to say nothing of observatories and other institutions, were at once founded, secondary education was developed, and in a few years the mental resources were so well looked after that Lord Palmerston defined the kingdom in question as 'a country of damned professors.'

After Sedan—a battle, as Moltke told us, 'won by the schoolmaster'—France made even more strenuous efforts. The old University of France, with its 'academies' in various places, was replaced by fifteen independent Universities, in all of which are faculties of letters, sciences, law and medicine.

The development of the University of Paris has been truly marvellous. In 1897–8 there were 12,000 students, and the cost was 200,000*l.* a year.

But even more wonderful than these examples is the 'intellectual effort' made by Japan, not after a war, but to prepare for one.

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The question is, Shall we wait for a disaster and then imitate Prussia and France; or shall we follow Japan and thoroughly prepare by 'intellectual effort' for the industrial struggle which lies before us?

Such an effort seems to me to be the first thing any national or imperial scientific organisation should endeavour to bring about.

Research.

When dealing with our Universities I referred to the importance of research, as it is now generally acknowledged to be the most powerful engine of education that we possess. But education, after all, is but a means to the end, which, from the national point of view, is the application of old and the production of new knowledge.

Its national importance apart from education is now so generally recognised that in all civilised nations except our own means of research are being daily more amply provided for all students after they have passed through their University career; and, more than this, for all who can increase the country's renown or prosperity by the making of new knowledge, upon which not only commercial progress, but all intellectual advance must depend.

I am so anxious that my statement of our pressing, and indeed imperative, needs in this direction should not be considered as resting upon the possibly interested opinion of a student of science merely that I must trouble you with still more quotations.

Listen to Mr. Balfour:—

'I do not believe that any man who looks round the equipment of our Universities or medical schools or other places of education can honestly say in his heart that we have done enough to equip research with all the costly armoury which research must have in these modern days. We, the richest country in the world, lag behind Germany, France, Switzerland, and Italy. Is it not disgraceful? Are we too poor or are we too stupid?'[1]

It is imagined by many who have given no thought to the matter that this research should be closely allied with some application of science being utilised at the time. Nothing could be further from the truth; nothing could be more unwise than such a limitation.

Surely all the laws of Nature will be ultimately of service, and therefore there is much more future help to be got from a study of the unknown and the unused than we can hope to obtain by continuing the study of that which is pretty well known and utilised already. It was a King of France, Louis XIV., who first commended the study of the *même inutile*. The history of modern science shows us more and more as the years roll on the necessity and advantage of such studies, and therefore the importance of properly endowing them; for the production of new knowledge is a costly and unremunerative pursuit.

[1] *Nature*, May 30, 1901.

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Years ago we had Faraday apparently wasting his energies and time in playing with needles; electricity now fills the world. To-day men of science in all lands are studying the emanations of radium; no research could be more abstract; but who knows what advance in human thought may follow or what gigantic world-transforming superstructure may eventually be raised on the minute foundation they are laying?

If we so organise our teaching forces that we can use them at all stages, from the gutter to the University, to sift out for us potential Faradays—to utilise the mental products which otherwise would be wasted—it is only by enabling such men to continue their learning after their teaching is over that we shall be able to secure the greatest advantage which any educational system can afford.

It is now more than thirty years ago that my attention was specially drawn to this question of the endowment of research—first, by conversations with M. Dumas, the permanent secretary of the Academy of Sciences, who honoured me by his friendship; and, secondly, by my association with Sir Benjamin Brodie and Dr. Appleton in their endeavours to call attention to the matter in this country. At that time a general scheme of endowment suggested by Dumas was being carried out by Duruy. This took the form of the 'École spéciale des Hautes Études'; it was what our fellowship system was meant to be—an endowment of the research of post-graduate students in each seat of learning. The French effort did not begin then.

I may here tell, as it was told me by Dumas, the story of Léon Foucault, whose many discoveries shed a glory on France and revived French industry in many directions.[1] In 1851, when Prince Napoleon was President of the Republic, he sent for Dumas and some of his colleagues, and told them that during his stay in England, and afterwards in his study of the Great Exhibition of that year, he had found there a greater industrial development than in France, and more applications of science, adding that he wished to know how such a state of things could be at once remedied. The answer was that new applications depended upon new knowledge, and that therefore the most direct and immediate way was to find and encourage men who were likely by research in pure science to produce this new knowledge. The Prince-President at once asked for names; that of Léon Foucault was the only one mentioned during the first interview.

Some time afterwards—to be exact, at about eleven in the morning of December 2—Dumas's servant informed him that there was a gentleman in the hall named Foucault, who wished to see him, and he added that he appeared to be very ill. When shown into the study, Foucault was too agitated to speak, and was blind with tears. His reply to Dumas's soothing questions was to take from his pockets two rolls of

[1] See *Proc. R. S.*, vol. xvii. p. lxxxiii.

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banknotes, amounting to 200,000 francs, and place them on the table. Finally, he was able to say that he had been with the Prince-President since eight o'clock that morning, discussing the possible improvement of French science and industry; and that Napoleon had finally given him the money, requesting him to do all in his power to aid the State. Foucault ended by saying that, on realising the greatness of the task thus imposed upon him, his fears and feelings had got the better of him, for the responsibility seemed more than he could bear.[1]

The movement in England to which I have referred began in 1872, when a society for the organisation of academical study was formed in connection with the inquiry into the revenues of Oxford and Cambridge, and there was a famous meeting at the Freemasons' Tavern, Mark Pattison being in the chair. Brodie, Rolleston, Carpenter, Burdon-Sanderson, were among the speakers, and the first resolution carried was, 'That to have a class of men whose lives are devoted to research is a national object.' The movement died in consequence of the want of sympathy of the University authorities.[2]

In the year 1874 the subject was inquired into by the late Duke of Devonshire's Commission; and after taking much remarkable evidence, including that of Lord Salisbury, the Commission recommended to the Government that the then grant of 1,000*l.*, which was expended, by a committee appointed by the Royal Society, on instruments needed in researches carried on by private individuals, should be increased, so that personal grants should be made. This recommendation was accepted and acted on; the grant was increased to 4,000*l.*, and finally other societies were associated with the Royal Society in its administration. The committee, however, was timorous, possibly owing to the apathy of the Universities and the general carelessness on such matters, and only one personal grant was made; the whole conception fell through.

Meantime, however, opinion has become more educated and alive to the extreme importance of research to the nation, and in 1891 a suggestion was made to the Royal Commission which administers the proceeds of the 1851 Exhibition that a sum of about 6,000*l.* a year available for scholarships should be employed in encouraging post-graduate research throughout the whole Empire. As what happened is told in the Memoirs of Lord Playfair, it is not indiscreet in me to state that when I proposed this new form of the endowment of research it would not have surprised me if the suggestion had been declined. It was carried through by Lord Playfair's

[1] In order to show how history is written, what actually happened on a fateful morning may be compared with the account given by Kinglake: 'Prince Louis rode home and went in out of sight. Then for the most part he remained close shut up in the Elysée. There, in an inner room, still decked in red trousers, but with his back to the daylight, they say he sat bent over a fireplace for hours and hours together, resting his elbows on his knees, and burying his face in his hands.'—*Crimean War*, vol. i. p. 215.

[2] See *Nature*, November and December, 1872.

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enthusiastic support. This system has been at work ever since, and the good that has been done by it is now generally conceded.

It is a supreme satisfaction to me to know that in this present year of grace the national importance of the study of the *même inutile* is more generally recognised than it was during the times to which I have referred in my brief survey; and, indeed, we students are fortunate in having on our side in this matter two members of His Majesty's Government, who two years ago spoke with no uncertain sound upon this matter:—

'Do we lack the imagination required to show what these apparently remote and abstract studies do for the happiness of mankind? We can appreciate that which obviously and directly ministers to human advancement and felicity, but seem, somehow or another, to be deficient in that higher form of imagination, in that longer sight, which sees in studies which have no obvious, necessary, or immediate result the foundation of the knowledge which shall give far greater happiness to mankind than any immediate, material, industrial advancement can possibly do; and I fear, and greatly fear, that, lacking that imagination, we have allowed ourselves to lag in the glorious race run now by civilised countries in pursuit of knowledge, and we have permitted ourselves so far to too large an extent to depend upon others for those additions to our knowledge which surely we might have made for ourselves.'[1]

'I would remind you that all history shows that progress—national progress of every kind—depends upon certain individuals rather than upon the mass. Whether you take religion, or literature, or political government, or art, or commerce, the new ideas, the great steps, have been made by individuals of superior quality and genius, who have, as it were, dragged the mass of the nation up one step to a higher level. So it must be in regard to material progress. The position of the nation to-day is due to the efforts of men like Watt and Arkwright, or, in our own time, to the Armstrongs, the Whitworths, the Kelvins, and the Siemenses. These are the men who, by their discoveries, by their remarkable genius, have produced the ideas upon which others have acted and which have permeated the whole mass of the nation and affected the whole of its proceedings. Therefore what we have to do, and this is our special task and object, is to produce more of these great men.'[2]

I finally come to the political importance of research. A country's research is as important in the long run as its battleships. The most eloquent teaching as to its national value we owe to Mr. Carnegie, for he has given the sum of 2,000,000*l.* to found a system of endowments, his chief purpose being, in his own words, 'to secure if possible for the United States of America leadership in the domain of discovery and the utilisation of new forces for the benefit of man.'

[1] Mr. Balfour, *Nature*, May 30, 1901.
[2] Mr. Chamberlain, *Times*, January 18, 1901.

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Here is a distinct challenge to Britain. Judging by experience in this country, in spite of the magnificent endowment of research by Mond and Lord Iveagh, the only source of possible competition in the British interest is the State, which certainly could not put the 1/8,000th part of the accumulated wealth of the country to better use; for without such help both our Universities and our battleships will become of rapidly dwindling importance.

It is on this ground that I have included the importance of endowing research among the chief points to which I have been anxious to draw your attention.

The Need of a Scientific National Council.

In referring to the new struggle for existence among civilised communities I pointed out that the solution of a large number of scientific problems is now daily required for the State service, and that in this and other ways the source and standard of national efficiency have been greatly changed.

Much evidence bearing upon the amount of scientific knowledge required for the proper administration of the public departments, and the amount of scientific work done by and for the nation, was brought before the Royal Commission on Science presided over by the late Duke of Devonshire now more than a quarter of a century ago.

The Commission unanimously recommended that the State should be aided by a scientific council in facing the new problems constantly arising.

But while the home Government has apparently made up its mind to neglect the advice so seriously given, it should be a source of gratification to us all to know that the application of the resources of modern science to the economic, industrial, and agricultural development of India has for many years engaged the earnest attention of the Government of that country. The Famine Commissioners of 1878 laid much stress on the institution of scientific inquiry and experiment designed to lead to the gradual increase of the food-supply and to the greater stability of agricultural outturn, while the experience of recent years has indicated the increasing importance of the study of the economic products and mineral-bearing tracts.

Lord Curzon has recently ordered the heads of the various scientific departments to form a board, which shall meet twice annually, to begin with, to formulate a programme and to review past work. The board is also to act as an advisory committee to the Government,[1] providing among other matters for the proper co-ordination of all matters of scientific inquiry affecting India's welfare.

Lord Curzon is to be warmly congratulated upon the step he has taken, which is certain to bring benefit to our great Dependency.

[1] *Nature*, September 4, 1902.

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The importance of such a board is many times greater at home, with so many external as well as internal interests to look after—problems common to peace and war, problems requiring the help of the economic as well as of the physical sciences.

It may be asked, What is done in Germany, where science is fostered and utilised far more than here?

The answer is, There is such a council. I fancy, very much like what our Privy Council once was. It consists of representatives of the Ministry, the Universities, the industries, and agriculture. It is small, consisting of about a dozen members, consultative, and it reports direct to the Emperor. It does for industrial war what military and so-called defence councils do for national armaments; it considers everything relating to the use of brain-power in peace—from alterations in school regulations and the organisation of the Universities, to railway rates and fiscal schemes, including the adjustment of duties. I am informed that what this council advises, generally becomes law.

It should be pretty obvious that a nation so provided must have enormous chances in its favour. It is a question of drilled battalions against an undisciplined army, of the use of the scientific spirit as opposed to the hope of 'muddling through.'

Mr. Haldane has recently reminded us that 'the weapons which science places in the hands of those who engage in great rivalries of commerce leave those who are without them, however brave, as badly off as were the dervishes of Omdurman against the maxims of Lord Kitchener.'

Without such a machinery as this, how can our Ministers and our rulers be kept completely informed on a thousand things of vital importance? Why should our position and requirements as an industrial and thinking nation receive less attention from the authorities than the headdress of the Guards? How, in the words of Lord Curzon,[1] can 'the life and vigour of a nation be summed up before the world in the person of its sovereign' if the national organisation is so defective that it has no means of keeping the head of the State informed on things touching the most vital and lasting interests of the country? We seem to be still in the Palæolithic Age in such matters, the chief difference being that the sword has replaced the flint implement.

Some may say that it is contrary to our habit to expect the Government to interest itself too much or to spend money on matters relating to peace; that war dangers are the only ones to be met or to be studied.

But this view leaves science and the progress of science out of the question. Every scientific advance is now, and will in the future be more and more, applied to war. It is no longer a question of an armed force with scientific corps; it is a question of an armed force scientific

[1] *Times*, September 30, 1902.

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from top to bottom. Thank God the Navy has already found this out. Science will ultimately rule all the operations both of peace and war, and therefore the industrial and the fighting population must both have a large common ground of education. Already it is not looking too far ahead to see that in a perfect State there will be a double use of each citizen—a peace use and a war use ; and the more science advances, the more the old difference between the peaceful citizen and the man at arms will disappear. The barrack, if it still exists, and the workshop will be assimilated ; the land unit, like the battleship, will become a school of applied science, self-contained, in which the officers will be the efficient teachers.

I do not think it is yet recognised how much the problem of national defence has thus become associated with that with which we are now chiefly concerned.

These, then, are some of the reasons which compel me to point out that a scientific council, which might be a scientific committee of the Privy Council, in dealing primarily with the national needs in times of peace, would be a source of strength to the nation.

To sum up, then. My earnest appeal to you is to gird up your loins and see to it that the science of the British Empire shall no longer remain unorganised. I have endeavoured to point out to you how the nation at present suffers from the absence of a powerful, continuous, reasoned expression of scientific opinion, urging in season and out of season that we shall be armed as other nations are, with efficient Universities and facilities for research to uphold the flag of Britain in the domain of learning and discovery, and what they alone can bring.

I have also endeavoured to show how, when this is done, the nation will still be less strong than it need be if there be not added to our many existing councils another, to secure that even during peace the benefits which a proper co-ordination of scientific effort in the nation's interest can bring shall not be neglected as they are at present.

Lest some of you may think that the scientific organisation which I trust you will determine to found would risk success in working on such large lines, let me remind you that in 1859, when the late Prince Consort occupied this Chair, he referred to 'impediments' to scientific progress, and said, 'they are often such as can only be successfully dealt with by the powerful arm of the State or the long purse of the nation.'

If the Prince Consort had lived to continue his advocacy of science, our position to-day would have been very different. His early death was as bad for Britain as the loss of a great campaign. If we cannot make up what we have lost, matters cannot mend.

I have done what I feel to be my duty in bringing the present condition of things before you. It is now your duty, if you agree with me, to see that it be put right. You can if you will.

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REPORTS

ON THE

STATE OF SCIENCE.

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REPORTS

ON THE

STATE OF SCIENCE.

Investigation of the Upper Atmosphere by Means of Kites in co-operation with a Committee of the Royal Meteorological Society.—Second Report of the Committee, consisting of Dr. W. N. SHAW (*Chairman*), Mr. W. H. DINES (*Secretary*), Mr. D. ARCHIBALD, Mr. C. VERNON BOYS, Dr. A. BUCHAN, Dr. R. T. GLAZEBROOK, Dr. H. R. MILL, *and* Professor A. SCHUSTER. (*Drawn up by the Secretary.*)

THE results of last year's work have been published; a description of the apparatus and methods employed being given in the 'Quarterly Journal of the Royal Meteorological Society,' vol. xxix., No. 126, p. 65; and a discussion of the results obtained, in a paper by Dr. Shaw and Mr. W. H. Dines, which appears in the 'Philosophical Transactions of the Royal Society,' series A, vol. ccii., 1903.

The apparatus used at Crinan last year was erected at Oxshott in the autumn, and it was hoped that to a limited extent the observations might be continued there; but before the end of October the wire was accidentally dropped across the main road leading from Esher to Leatherhead. Fortunately the wire rested on trees on both sides of the road; but before it could be removed many carriages and bicyclists had passed under it. This accident convinced us that it would be unwise to continue the work at Oxshott, excepting for winds between south and north-west. The winter has been devoted to an endeavour to improve the apparatus. This has been accomplished: a new winding-gear has been constructed, which so far has given every satisfaction, and the details of the construction of the kites have been altered, so that they exert a more uniform pull and seem to be more reliable. The apparatus was brought to Crinan at the beginning of August, and in view of the uncertainty about obtaining a vessel, was erected on the same island as last year. The apparatus in the possession of the Committee now consists of—

I. Engine, boiler, and winding-gear used last year.

II. New winding-gear.

III. About 14 miles of wire, six of which have been purchased this year.

IV. Ten kites 7 feet 6 inches high; three kites 9 feet high; materials of a kite 12 feet high.

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V. Two self-recording instruments made by Mons. Tesserenc de Bort.[1]
VI. Spare bamboo sticks, &c., for repairs.

The old winding-gear is hardly reliable, but many of the parts will be available for making another.

Application was made to the Government Grant Committee of the Royal Society for a grant of 250*l.* for the hire of a vessel. On the suggestion of this Committee the Admiralty were asked to lend a vessel for the purpose, and they kindly consented to do so; but unfortunately the vessel they proposed to place at the disposal of the Kite Committee has met with an accident and is unavailable. The Royal Society have, however, made a grant of 200*l.*, and the Committee are now endeavouring to hire a suitable vessel.

Addendum to the Report of the Kite Committee.

Great difficulty has been experienced in obtaining a suitable vessel owing to the lateness of the time at which inquiries about one were instituted and to the fact that July and August are the yachting season. A steam tug, the 'Renown,' has been hired for a month, and reached Crinan on August 13. The apparatus was fitted on board by the evening of the 14th, and since then daily ascents have been made. No great height (over 6,000 feet) has been reached, for the weather has been of the most unfavourable description for kite flying; but one very interesting trace has been obtained—namely, that of August 20, when the kite was drawn in from a height of 4,500 feet during a sudden and unexpected thunderstorm which was accompanied by extremely violent rain and hail.

Magnetic Observations at Falmouth.—Report of the Committee, consisting of Sir W. H. PREECE (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Professor W. G. ADAMS, Captain CREAK, Mr. W. L. FOX, Professor A. SCHUSTER, *and* Sir A. W. RÜCKER, *appointed to co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.*

THE Committee report that the grant voted at the last meeting has been used in support of the ordinary magnetic work of the Falmouth Observatory, and that records of the horizontal force, the declination, and the vertical force have been kept during the year. The curves up to December 31, 1902, have been examined at Kew, and, specially in view of the disturbed state of the Kew instruments and the uncertainty as to the future magnetic observatory to replace Kew, have a real value.

The results for the quiet days are published in the Report of the Falmouth Observatory, and will be reprinted in the Proceedings of the Royal Society.

The vertical force instrument to which reference was made in the last report has worked in a fairly satisfactory manner during the year.

In conclusion the Committee ask for reappointment with a further

[1] A third is promised by him and expected shortly.

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grant of 60*l*. The reasons for this request are in the main the same as last year. It has not yet been found possible to establish the new magnetic observatory and to remove the recording instruments from Kew, though the Committee are informed that progress has been made in the arrangements for this; at the same time electric traction has increased greatly in the neighbourhood of Kew, and the records are in consequence very seriously disturbed. Thus the Falmouth records are of special importance to science just now.

Experiments for improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Lord RAYLEIGH (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Lord KELVIN, Professors W. E. AYRTON, J. PERRY, W. G. ADAMS, *and* G. CAREY FOSTER, Sir OLIVER J. LODGE, Dr. A. MUIRHEAD, Sir W. H. PREECE, Professors J. D. EVERETT, A. SCHUSTER, J. A. FLEMING, *and* J. J. THOMSON, Dr. W. N. SHAW, Dr. J. T. BOTTOMLEY, Rev. T. C. FITZPATRICK, Dr. G. JOHNSTONE STONEY, Professor S. P. THOMPSON, Mr. J. RENNIE, Dr. E. H. GRIFFITHS, Sir A. W. RÜCKER, Professor H. L. CALLENDAR, *and* Mr. GEORGE MATTHEY.

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DURING the year a very complete comparison of the resistance standards belonging to the Association has been carried out, and the standards have been compared with those of the Reichsanstalt and of the Board of Trade.

The various units discussed in the report are: (1) The 'ohm,' 10^9 C.G.S. units of resistance; (2) the international ohm—viz., the resistance at 0° C. of a column of mercury of uniform section 106·3 cm. in length and 14·4521 grammes in mass; (3) the original B.A. unit; (4) the Board of Trade unit, supposed to represent the international ohm, but constructed in 1891 so as to be equal to 1·01358 B.A. units; (5) the N.P.L. unit defined as No. 4, as deduced from the wire standards of the Association; (6) the Reichsanstalt unit, constructed at the Reichsanstalt to represent the international ohm; (7) the mercury tubes, constructed at the National Physical Laboratory to represent the international ohm.

A full account of this comparison is given in Appendix I. to the report, by Mr. F. E. Smith, of the National Physical Laboratory. It appears from this that changes have shown themselves in all the original platinum-silver coils. The relative values of these coils are discussed in the Reports of the Committee for 1888, 1890, and 1892. The 1888 report contains a very complete comparison of all the coils, not merely those of platinum-silver; and it is there shown that they then agreed with the values

assigned to them by Fleming in 1881. The conclusion is also drawn in the same report that, with the exception of the platinum-iridium coils A and B, no really certain variations could be traced in the other coils between the results of Matthiessen and Hockins's comparisons in 1864 and 1867, those of Chrystal in 1876, Fleming in 1881, and the present Secretary[1] in 1888. A postcript to the Report for 1888 recorded, however, an appreciable change in the coil F in the autumn of that year.

In Appendix I. Mr. Smith starts with the values given in the 1888 Report, which are, as nearly as we can tell, the original values of the coils.

Changes in the three standards F, G, H have already been recorded in previous Reports (1890 and 1892). The standard coil Flat remained unchanged in value until 1901–1902. Between the observations recorded in these years it increased in resistance by 17×10^{-5} B.A.U., and has not varied since.

The alterations in the other coils since the comparisons in 1888 have been as follows :—

F. $+ 97 \times 10^{-5}$ B.A.U.
G. $+ 33 \times 10^{-5}$ „
H. $+ 18 \times 10^{-5}$ „

It should however be noted that, while between 1888 and 1890 the change in F was $+64 \times 10^{-5}$ B.A.U., that in G was -27×10^{-5}, and in H -13×10^{-5}. Since 1890 the same coils changed by $+33 \times 10^{-5}$ $+54 \times 10^{-5}$, and $+31 \times 10^{-5}$ B.A.U. respectively, while between 1901 and 1902 Flat, as has already been stated, rose by 17×10^{-5} B.A.U.

It is not easy to trace the causes of these changes. In the case of Flat the observations in 1901 were made at Kew, those in 1902 at Bushy House, and the change may in some way be connected with the removal of the coils. The changes in F, G, H first showed themselves after the coils had been subject to a very low temperature, and may have been started by strains due to this.

Appendix I. gives the details on which these various statements are based. It appears also from the same Appendix that the new platinum-silver ohm standards of the Association have retained their values since 1898 practically unchanged.

The comparison between the standards of the Association and those of the Reichsanstalt leads to the result that the unit of the Association (No. 5 of those defined above) is less than that of the Reichsanstalt (No. 6) by ·000105 ohm. This result is deduced (Table IX. of Appendix I.) from a series of extremely concordant measures on coils of value 0·1, 1, 10, 100, 1,000, and 10,000 ohms; thus both the unit and the multiple coils agree in giving the same difference between the Reichsanstalt and ourselves.

By the kindness of Mr. Trotter a comparison has been made between the Board of Trade unit and those of the Association, with the result that, as deduced from the unit coils, the Board of Trade unit is less than that of the Association by ·00006 ohm. This result, however, is not confirmed by a comparison of a 1,000-ohm coil belonging to the Associa-

[1] It is possible that coil F is an exception to this statement.

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tion with one of those of the Board of Trade;[1] these coils show no difference.

The above statements are made on the assumption that the various changes in the coils which have undoubtedly occurred have been rightly interpreted, so that we can now recover the absolute C.G.S. value of the coil Flat, and hence of the standard ohm as originally determined at the Cavendish Laboratory, and defined by the Committee in the Edinburgh Report, 1892.

That this is the case is borne out by the results of the experiments on the specific resistance of mercury, a summary of which is given in Appendix II. These are not yet complete. Mr. Smith has, however, constructed and calibrated eleven mercury tubes. The mean cross-section of each of these has been determined by at least four different sets of measurements. In nine cases the greatest difference between any measurement and the mean is not more than ·001 per cent.

The values found for the resistance of each tube do not differ by more than ·001 per cent.

If we assume as above that the values of the wire standards of resistance of the Association are known in terms of the absolute C.G S. unit, then it follows that the length of the column of mercury, one square millimetre in section, which would have a resistance of 10^9 C.G.S. units, would be 106·291 centimetres. The value found for this same quantity by the Secretary (Mr. Glazebrook) and Mr. Fitzpatrick in 1888,[2] was 106·29 centimetres. We infer then that we still can recover from our standard coils the absolute C.G.S. unit of resistance.

Again, the length of the mercury column constituting the international ohm has been defined as 106·3 cm.

But we have seen that the absolute C.G.S. unit as deduced from the wire coils of the Association has a resistance equal to that of 106·291 cm. Thus the absolute unit[3] is smaller than the international ohm by ·009 per cent. Again, it has been stated above that the unit deduced from the standards of the Association is smaller than that of the Reichsanstalt by $\cdot 010_5$ per cent.

Thus the mercury standards of the Reichsanstalt, constructed to represent the international ohm, exceed those just made for the Association by Mr. Smith by $\cdot 001_5$ per cent., or 1·5 parts in 100,000.

Again, if these results be accepted, since the Board of Trade unit, as derived from the wire standards, is less than that of the Association by ·006 per cent., and the Association unit is too small by ·009 per cent., it follows that the Board of Trade unit is too small by ·015 per cent. This difference arises in part from the fact that the standards of the Association, from which the Board of Trade standard was copied by the Secretary in 1891, are too low; in part from the fact that the Board of Trade standard has diverged slightly from that of the Association since 1891.

[1] If the view be accepted that the laboratory unit is the same as in 1891, the Board of Trade standard has fallen since that date by ·00006 ohm.

[2] *Phil. Trans.* 1888.

[3] The resistance taken for a column of mercury 1 square mm. in section, 100 cm. in length at 0° C. at the Edinburgh Meeting in 1892, was $\cdot 9407 \times 10^9$ C.G.S. units. Mr. Smith's experiments give, assuming the values of the wire coils known, the result $\cdot 9408 \times 10^9$ C.G.S. units.

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Thus, to sum up this part of the Report, it may be stated that :—

(*a*) The original B.A. unit and the standard ohm based on it (Nos. 3 and 5 of the units concerned) can be recovered from the wire coils of the Association.

(*b*) The Board of Trade unit (No. 4) is now less than the Laboratory unit (No. 5) by ·006 per cent.

(*c*) The Laboratory unit (No. 5) is less than the international ohm (No. 2) by ·009 per cent.

(*d*) The Board of Trade unit is less than the international ohm by ·015 per cent.

(*e*) The mercury tubes made at the National Physical Laboratory to represent the international ohm are less than those made at the Reichsanstalt by ·0015 per cent.

This last result must be considered as provisional pending the completion of Mr. Smith's work, but it is clearly highly satisfactory.

Mr. Smith has also made progress during the year with his investigations into certain of the anomalies shown by Clark cells, but the results of that inquiry are not yet ready for publication.

The standard condensers of the Association have been frequently in use during the year; about fifteen condensers have been compared with them. They retain their value in a satisfactory manner, and are convenient to work with, though possibly some improvement in the insulation might be desirable.

A chronograph, purchased with part of the grant made last year, will enable the time measurements required in the measurement of capacity to be made with greater accuracy, and hence will permit of greater rigidity in the inquiry as to the permanence of the standards.

The platinum thermometers made from the stock of wire purchased from Messrs. Johnson and Matthey, which at the time of the last Report were in course of construction, have been completed, and the behaviour of some of them investigated throughout the past year. The resistance-box available was the old Callendar-Griffiths box used in the work of Dr. Chree at Kew Observatory, having coils of platinum-silver on the binary system. The contacts are an old form of the Cambridge Instrument Company's type of plug-contact, the cheeks being made of a special white alloy held in round Doulton-ware cups. In measurements with this box not much significance attaches to the third figure of decimals representing hundred-thousandths of an ohm, though the settings could be made to this amount at the lower temperatures. The box resistance-coils were intended for use with platinum thermometers of 1 ohm fundamental interval only, and therefore the two high-resistance thermometers, of 5 ohms fundamental interval, could not be measured at the sulphur-point; their systematic investigation has therefore been temporarily postponed. The want of a better box for this work is seriously felt.

Of the original six thermometers made in August 1902, Nos. 1 to 4 are of 1 ohm fundamental interval, Nos. 1 and 2 being in porcelain and 3 and 4 in specially thin Jena glass tubes of internal diameter 8 to 9 mm. and 38 to 40 cm. long. Nos. 5 and 6 are of 5 ohms fundamental interval,

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and in somewhat wider tubes of specially thin glass, through which the four leads are hermetically sealed. The heads of all these thermometers are of the design used by Chappuis and Harker, the contacts to the solid ends of the copper flexibles being made by fusible metal cups. With reasonable care these contacts prove very satisfactory, both as regards the constancy of their resistance and their mechanical strength.

In the construction of all these thermometers special care was devoted to adjusting their fundamental intervals to be very close to their nominal values, and after completing this adjustment all were subjected to repeated annealing in air at a bright-red heat, thermometers Nos. 3 and 4 being temporarily placed in porcelain tubes for the purpose.

The remaining four constructed last summer, and one of later date, all of 1 ohm fundamental interval, have had their constants determined from time to time during the year. One of them—B.A.$_2$—was selected as a representative platinum thermometer for use in an investigation made to determine the relation between the platinum scale and that of the gas thermometer of the National Physical Laboratory at temperatures up to 1000° C During the time occupied by two sets of experiments with this instrument, extending over about three months in all, its constants altered by an amount only just greater than their probable error, showing that it is quite possible to use properly constructed platinum thermometers up to temperatures slightly over 1000° C. for long periods without fear of serious changes.

The summary of the life history of the different thermometers is given in Appendix III. The chief fact apparent is that there seems to be a small but real difference between the δ of thermometers 1 and 3 on the one hand, and 2, 4, and 7 on the other, the maximum divergence being about ·02.

Prolonged electrical heating in air of the wire of one of the thermometers was not found to sensibly change the value of the δ. The cause of the small differences found is not obvious, and further investigation is being made on this point.

A change in δ from 1·50 to 1·51 would make at the sulphur-point a difference of 0°·153 C., and at 1000° C. one of 0°·9.

The question of the resistance of copper has been raised lately by the work of one of the sub-Committees of the Engineering Standards Committee. For commercial purposes the resistance of copper is defined at a temperature of 60° Fahr. (15°·55 C.). A table in Appendix IV. gives the values that have been found by various experimenters.

It is clear that copper is now prepared of a higher degree of purity than in the time of Matthiessen. Taking the mean of the figures in the table for modern electrolytic copper, we have as the value of the resistance of 1 metre of copper wire weighing 1 gramme at 15°·55 C. the value $0{\cdot}1485_5$ ohm, but the figures of which this is a mean range from 1475 to 1492. The value found by Matthiessen, as deduced from his paper in the 'Phil. Trans.' for 1860, is 0·1500 ohm. Thus the conductivity of modern pure electrolytic copper is 1 per cent. better than Matthiessen's.

The Committee on copper conductors, which investigated the question in 1899, adopted the number 0·1508 ohm as the resistance of a metre-gramme of commercial annealed high-conductivity copper. This figure has been accepted by the Engineering Standards Committee.

Mr. H. A. Taylor has recently placed in the hands of the Secretary

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two resistances of gold-silver wire made by Matthiessen himself, to represent the resistance at 15°·5 C. of 100 inches of pure annealed copper, having the weight of 100 grains. The resistances of these coils have been determined by Mr. Smith, and the results are given in the following table :—

—	Coil No. 1	Coil No. 2
Resistance of 100 inches of copper weighing 100 grains, as given by Matthiessen in B.A. units at 15°·5 C.	·1516	·1514
Resistance found in 1903 in B.A. units at 15°·5 C.	·1513$_3$	·1513$_3$
Resistance found reduced to ohms at 15°·5 C.	·1493$_3$	·1492$_9$
Resistance deduced of a metregramme in ohms at 15°·5 C.	·1499$_4$	·1499$_4$

Thus Matthiessen's value for the resistance of annealed copper at 15°·55 C. (60° Fahr.) as deduced from these coils, agrees very closely with the value calculated by the Secretary from the figures in his 1860 paper.

The Committee have had under consideration the drawings and specifications for the ampere balance as designed by the late Principal Viriamu Jones and Professor Ayrton. The electrical parts of the instrument need construction under skilled supervision. Tests of various kinds have to be made continually, and the Committee have come to the conclusion that this supervision can best be secured by having the instrument constructed in the workshop of the National Physical Laboratory, under the care of Professor Ayrton and the Secretary, who, as Director, will be able, with the assistance of the staff of the Laboratory, to control the work in an efficient manner.

The Committee are of opinion that further expenditure will be required in completing the set of platinum thermometers, in particular in providing a satisfactory resistance-box and in carrying out the researches on the Clark cell. They consider that it is of great importance that these researches should be brought to a satisfactory conclusion.

For these reasons they recommend that they be reappointed, with a grant of 60*l.*, that Lord Rayleigh be Chairman, and Mr. R. T. Glazebrook Secretary.

APPENDIX I.

On the Values of the Resistance of certain Standard Coils of the British Association. *By* F. E. Smith.

(*From the National Physical Laboratory.*)

[The Report covers the period 1888–1903 inclusive.]

Changes of very considerable magnitude have taken place since 1892 in the old B.A. standards. The removal of the coils, first to Liverpool, then to Kew, and finally to Teddington, has resulted in the comparisons being incomplete in some years. In consequence the difficulty of locating differences has correspondingly increased.

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The observations recorded are in terms of B.A. Flat. Owing to a change in Flat taking place, however, the 1903 comparisons were made chiefly with Nalder 3715.

In Table I. the approximate difference in B.A.U. between Flat and the B.A. unit coils F, G, H of the Association are given.

Table II. gives the difference in ohms between[1] (1·01358 × Flat) and other platinum-silver coils. Temperature of observations, 16° C.

TABLE I.

Year	Flat		
	F	G	H
1888	$+47\times10^{-5}$	$+91\times10^{-5}$	$+77\times10^{-5}$
1890	−17	+112	+90
1891	—	—	—
1892	−18	+108	+92
1894	—	—	—
1897	—	—	—
1898	−36	+99	+69
1900	−47	+92	+63
1901	−42	+92	+70
1902	−33	+90	+76
1903	−33	+75	+76

TABLE II.

(1·01358 × Flat)			
Nalder 3715	Elliott 264	Elliott 269	Elliott 270
—	—	—	—
—	—	—	—
—	$+13\times10^{-5}$	—	—
—	—	—	—
-17×10^{-5}	—	-37×10^{-5}	$+27\times10^{-5}$
—	—	—	—
−17	+9	−46	+27
−17	+23	−59	+27
−17	+23	−54	+27
0	+38	−39	+44
0	—	−39	+44

Table III. shows the percentage difference between (1·01358 × Flat) and the unit of two 10-ohm platinum-silver coils of the Association at 16° C.

TABLE III.

Year	(1·01358 × Flat)	
	Elliott 288	Elliott 289
1897	-27×10^{-5}	$+7\times10^{-5}$
1898	−27	+7
1902–3	−10	+24

The coils F, G, and H are similarly constituted: they are the old B.A. coils made by Matthiessen. No. 3715 is by Nalder Bros., and the remainder of the coils by Messrs. Elliott Bros. No. 264 is a coil belonging to the Board of Trade, and has been returned to Whitehall; hence there are no observations for 1903.

Tables I., II., and III. assume Flat to be constant. It will be observed that the differences of Flat and 3715, 270, 288, and 289 are constant from 1897 to 1901. From 1901 to 1903 a change of about ·017 per cent. is evident between Flat and the coils 3715, 264, 269, 270, and again between Flat and the units of the coils 288 and 289. This suggests a change in the value of Flat from 1901.

Since 1901 comparisons between Flat and the manganin standards of the Association have been made. Table IV. gives the observed values in ohms.

[1] 1 B.O.T. ohm = 1·01358 B.A.U.

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TABLE IV.—*Values at* 16° *C. in terms of* (1·01358 × *Flat*), *assuming Flat unchanged.*

Year	Wolff 1690	Wolff 780	Wolff 381	Wolff 147
1901	1·00012	1·00002	1·00014	·99790
1902	·99995	·99987	·99999	·99783
1903	·99995	·99987	·99999	·99783

The values of 1690, 780, 381, and 147 diminish by 17, 15, 15, and 7 times 10^{-5} ohms respectively in the interval 1901–1902. No. 147 is known to be a variable coil of very low insulation-resistance, and may be disregarded for the purpose of estimating the change in Flat. It is of interest as being a coil brought to Cambridge by Dr. Lindeck in 1892 and left with the Secretary.

Thus the apparent *falls* in value of 3715, 264, 269, 270, 288, 289, 1690, 780, and 381 are respectively ·017, ·015, ·020, ·017, ·017, ·017, ·017, ·015, and ·015 per cent., giving a mean of ·017 per cent.

This justifies the assumption of a *rise* in resistance of B.A. Flat of ·017 per cent. in the period 1901–1902.

The following tables, V. and VI., are I. and II. revised. They take the change in Flat into account by means of corrections applied to the observations of the years 1902 and 1903. The values given are for 16° C.

TABLE V. (I. *Revised*).

B.A.U.

Year	Constant Flat		
	F	G	H
1888	$+47\times10^{-5}$	$+91\times10^{-5}$	$+77\times10^{-5}$
1890	−17	+112	+90
1891	—	—	—
1892	−18	+108	+92
1894	—	—	—
1897	—	—	—
1898	−36	+99	+69
1900	−47	+92	+63
1901	−42	+92	+70
1902	−50	+73	+59
1903	−50	+58	+59

TABLE VI. (II. *Revised*).

Ohms.

Year	Constant (1·01358 × Flat)			
	Nalder 3715	Elliott 264	Elliott 269	Elliott 270
1888	—	—	—	—
1890	—	—	—	—
1891	—	$+13\times10^{-5}$	—	—
1892	—	—	—	—
1894	-17×10^{-5}	—	-37×10^{-5}	$+27\times10^{-5}$
1897	—	—	—	—
1898	−17	+ 9	−46	+27
1900	−17	+23	−59	+27
1901	−17	+23	−54	+27
1902	−17	+21	−56	+27
1903	−17	—	−56	+27

Tables VII. and VIII. being III. and IV., similarly revised, show no marked change in any of the coils in those tables excepting 147.

TABLE VII. (III. *Revised*).

Values at 16° *C.*

Year	(1·01358 × Flat)	
	Elliott 288	Elliott 289
1897	$-\cdot27\times10^{-5}$	$+7\times10^{-5}$
1898	−·27	+7
1902–3	−·27	+7

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TABLE VIII. (IV. *Revised*).

Year	Wolff 1690	Wolff 780	Wolff 381	Wolff 147
1901	1·00012	1·00002	1·00014	·99790
1902	1·00012	1·00004	1·00016	·99800
1903	1·00012	1·00004	1·00016	·99800

With reference to Tables V. and VI. the data for 1901–1903 show a rise of ·008 per cent. for F, ·034 per cent. for G, and ·011 per cent. for H, indicating that they are certainly changing coils, the resistance for this period increasing with time.

From the values recorded 3715 and 270 we have evidence that Flat has probably remained constant for the period 1894–1901. Also we infer that 264 is not a coil showing *very* great changes.

Between the years 1892 and 1898 the differences between Flat and the coils F, G, and H alter by the amounts ·018 per cent., ·009 per cent., and ·023 per cent. respectively. The dissimilarity of these percentage-differences is further evidence that the coils have changed amongst themselves in this period. Comparing the amounts with those of the period 1901–1903, they represent quite normal increments of resistance. The balance of evidence in consequence is in favour of the constancy of Flat over the period 1892–1898, and this constancy has therefore been assumed.

A summarised statement of the platinum-silver coils of the Association will now be as follows :—

TABLE IX.—*Showing the Percentage-increase in Resistance of B.A. Platinum-silver Coils from* 1888.

Coil	1888	1890	1891	1892	1894	1897	1898	1900	1901	1902	1903
Flat	—	—	—	—	—	—	—	—	—	·017	·017
F	—	·064	—	·065	—	—	·083	·094	·089	·097	·097
G	—	−·021	—	−·017	—	—	−·008	−·001	−·001	·018	·033
H	—	−·013	—	−·015	—	—	·008	·014	·007	·018	·018
3715	—	—	—	—	obs. commence	—	0	0	0	0	0
264	—	—	obs. commence	—	—	—	·004	−·010	−·010	−·008	—
269	—	—	—	—	obs. commence	—	·009	·022	·017	·019	·019
270	—	—	—	—	obs. commence	—	0	0	0	0	0
288	—	—	—	—	—	obs. commence	0	—	—	—	0
299	—	—	—	—	—	obs. commence	0	—	—	—	0

It will be observed that a number of the coils are steadily rising in value. The insulation remains good.

Temperature Coefficients of B.A. Coils.

Some special observations have been made in order to obtain the temperature coefficients of the coils. These were carried out by keeping the standard coil constant and subjecting the tested coil to various temperatures for twelve or more hours so as to ensure no lag. It is

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interesting to note that the temperature coefficients of some of the coils are appreciably different from the old values of 1892.

TABLE X.—*Showing the old and new values of the Temperature Coefficients of various Coils.*

Coil	Temperature Coefficient Old value, per 1° C.	Temperature Coefficient New value, per 1° C.
Flat	·000277 B.A.U.	·000271 B.A.U.
F	286 ,,	268 ,,
G	274 ,,	274 ,,
H	271 ,,	280 ,,
3715	·000260? ohm	·000307 ohm
264	312 ,,	283 ,,
269	—	285 ,,
270	—	315 ,,

Comparison of the Unit of Resistance employed at the Reichsanstalt and that of the N.P.L.

By the N.P.L. unit is meant the unit of resistance as obtained from the old B.A. coils.[1] Assuming that all the changes have been successfully interpreted, the unit at present employed in the Laboratory should be the same as that employed in the Cavendish Laboratory in 1898 and at Edinburgh in 1892.

A comparison of the two units was rendered possible in the spring. Two Wolff coils, Nos. 780 and 738, of nominal values 1 ohm and 10 ohms respectively, were despatched to Germany last winter. Their values were determined in Reichsanstalt units (termed international ohms) in March, and the coils immediately returned to the Laboratory. Unfortunately both coils fell in value two or three parts in the hundred-thousandth figure during their journeyings. The values given in the table are those determined on their return.

In addition, five new coils were received varying in value from $\frac{1}{10}$th to 10,000 ohms. These enabled a more complete comparison to be made. The Laboratory value was deduced by building up from the unit, and also by direct comparison with coils of similar value.

TABLE XI.—*Results of Measurements of various coils at the Reichsanstalt and at the Laboratory, March* 1903.

Coil No.	Laboratory Value at 17° C.	Value Deduced from Reichsanstalt Certificate at 17° C.	Laboratory Value − Reichsanstalt Value. Percentage Difference
2352	·100007	·099996	·011 per cent.
2351	1·00011	1·00001	·010 ,,
780	1·00001	·99991	·010 ,,
738	9·9994$_5$	9·9985	·009$_5$,,
2450	100·004	99·993	·011 ,,
2449	1000·06	999·96	·010 ,,
2448	10000·9	9999·8	·011 ,,

[1] 1 N.P.L. unit = 1·01358 B.A.U

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It is evident from these observations that a difference of $\cdot 010_5$ per cent. exists, or that—

Resistance of Reichsanstalt unit—Resistance of Laboratory unit
$= \cdot 00010_5$ ohm . . . . . (A)

Comparison of the Unit of Resistance employed at the Board of Trade and that of the Laboratory.

The comparison of these two units is not so complete. Two platinum-silver units and one of manganin have been determined at both laboratories. The measurements taken at Teddington indicate that no change resulted during the journeyings of the coils. In addition one 1,000-ohm coil (Nalder 6863) has been determined.

TABLE XII.—*Results of Measurements of various coils at the Board of Trade Offices and at the Laboratory, February and March* 1903.

Coil No.	Temperature	Laboratory Value	Deduced B.O.T. Value	Laboratory Value—B.O.T.
Elliott, 270	16°·0 C.	1·00006	$1 \cdot 00010_5$	$-\cdot 004_5$ per cent.
Elliott, 264	16°·0 C.	1·00008	$1 \cdot 00014_5$	$-\cdot 006_5$,,
Wolff, 381	16°·0 C.	1·00015	$1 \cdot 00021_7$	$-\cdot 006_7$,,
Nalder, 6863	15°·84 C.	999·13	$999 \cdot 1_3$	—

The exact relationship between the B.O.T. unit and that of the Laboratory is therefore still incomplete. It seems fairly certain however that—

Resistance of Laboratory unit—Resistance of B.O.T. unit
$= \cdot 00006$ ohm, a difference of ·006 per cent. . . (B)

From the two relationships—

Resistance of Reichsanstalt unit—Resistance of N.P.L. unit
$= \cdot 00010_5$ ohm
Resistance of Laboratory unit—Resistance of B.O.T. unit
$= \cdot 00006$ ohm

we have

Resistance of Reichsanstalt unit—Resistance of B.O.T. unit
$= 00016_5$ ohm, a difference of $\cdot 016_5$ per cent. . . (C)

The present values of the B.A. coils are as follows :—

TABLE XIII.

Coil	Temperature	Resistance	Temperature Coefficient per 1° C.
Flat	16°·0 C.	1·00050 B.A.U.	·000271 B.A.U.
F	,,	1·00083 ,,	·000268 ,,
G	,,	99975 ,,	·000274 ,,
H	,,	·99976 ,,	·000280 ,,
3715	,,	1·00050 ohm	·000307 ohm
269	,,	1·00039 ,,	·000285 ,,
270	,,	1·00006 ,,	·000315 ,,
288	,,	10·0060 ,,	$\cdot 0031_0$,,
289	,,	10·0026 ,,	$\cdot 0026_5$,,

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The Wolff manganin coils of the Association are also given at 16° C., with a temperature coefficient to be applied for small ranges of temperature only, since it is by no means a linear function.

TABLE XIV.

Coil	Temperature	Resistance	Temperature Coefficient per 1° C.
1690	16°·0 C.	1·00012 ohm	·00001 ohm
780	,,	1·00002 ,,	·00001 ,,
381 [1]	,,	1·00016 ,,	·00002 ,,
147	,,	·99800 ,,	·00001$_8$,,

As has already been explained, the values are given in terms of the Laboratory unit which represents 10^9 C.G.S. units of resistance as determined by Lord Rayleigh and Mr. Glazebrook at Cambridge; it has been assumed that the inter-comparison of the coils enables that unit to be recovered.

Appendices I. and II. of the present Report afford the means of connecting this unit with those of the Board of Trade, derived from it in 1891, and of the Reichsanstalt, and also with the ohm or international ohm—the resistance, that is, of a certain column of mercury.

APPENDIX II.

The relation between the international ohm (106·300 *cm. Hg. weighing* 14·4521 *gms. at* 0° *C.*) *and the unit of resistance employed at the N.P.L. Preliminary Note, by* F. E. SMITH.

(From the National Physical Laboratory.)

The following measurements of six mercury tubes indicate the progress made in this inquiry, and also the relation obtained :—

Tube	L	Conical Correction	Theoretical Length for 1 Int. Ohm.	a	b	b—a
	Length at 0° C.	$(\mu-1)\times10^6$		Calculated Resistance of Tube. Int. Ohm	Mean Measured Resistance. Lab. Unit	
U	62·0731	5_6	62·1319	·99905	·99913	·00008
V	73·5000	18	73·4759	1·00033	1·00041	·00008
G	116·507	9	116·478	1·00025	1·00035	·00010
X	65·6338	2_8	65·6354	0·99997	1·00007	·00010
Y	62·1867	15	62·2382	·99917	·99926	·00009
Z	68·5199	8	68·5057	1·00021	1·00029	·00008

Thus, Laboratory Unit of Resistance = ·99991 Int. ohm.

$$= \frac{106\,291}{106{\cdot}300} \text{ Int. ohm.}$$

[The above figures are intended as merely provisional.]

[1] No. 381 is a manganin coil belonging to the Board of Trade.

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With respect to the measurements of the cross-sections the uniformity of the results show that an accuracy of ·001 per cent. may be relied upon. Four methods of measuring the resistance will be employed. At present only two of these are completed. The values in each horizontal line refer to different fillings; they are quite concordant, as the values given in the following table show :—

Resistance in Laboratory (N.P.L.) Units of Mercury Tubes.

Tube	Resistance at 0° C. Potentiometer	Resistance at 0° C. Kelvin Double Bridge
U	·99913	·99913
	·99912	·99912
	·99914	·99914
V	1·00041	1·00041
	1·00044	1·00044
	1·00040	1·00039$_5$
G	1·00034	1·00033
	1·00036	1·00036
	1·00035	1·00035
X	1·00007	1·00007
	1·00006	1·00006
	1·00007	1·00006
Y	·99926	·99926
	·99927	·99926
	·99925	·99925
Z	1·00030	1·00030
	1·00029	1·00029
	1·00029	1·00029

APPENDIX III.

On the Platinum Thermometers of the British Association.
By J. A. Harker, *D.Sc.*

(*From the National Physical Laboratory.*)

The four platinum thermometers numbered BA_1 to BA_4, with which this Appendix chiefly deals, were constructed at the National Physical Laboratory in August 1902. The wire used for the 'bulbs' is approximately ·006 in. (·15 mm.) diameter, and for the leads ·020 in. (·5 mm.).

After ascertaining approximately the length of wire necessary to give a fundamental interval of 1 ohm, the proper amount for the four thermometers was cut off from the stock reel, and heated in one piece to moderate redness (800° C.) electrically when supported approximately horizontal. The platinum 'lead' wires, which were of the same quality of pure metal as the finer 'bulb' wire, were then measured off and the pairs assigned to each thermometer accurately matched. After a preliminary anneal in an oxidising atmosphere at a bright red heat, one of each of

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these pairs was looped upon itself to form the compensator, and the other cut in half for attachment to the ends of the 'bulb' wire. Several kinds of mica from different sources were tested as to their suitability for use as insulating material for the frame and washers to support the wires, and it was found that considerable discrimination was necessary in the selection of the mica for this purpose. Certain qualities which were colourless before heating became on exposure to only 800° to 850° of a marked brown tint, and it was found in one case this was due to organic material having been used to fasten together several sheets to build up the necessary thickness, the carbonaceous matter leading to a fall in insulating power several hundred degrees below the temperature at which good mica begins to appreciably conduct, which ought not to be lower than 1150° C. In another case, a specimen which showed the characteristic silvery white lustre after several hours' exposure to 1100° C., had lost so much of its mechanical strength as to be almost unusable. A specimen which before heating was of slightly green tint was finally selected, and of this the whole of the mica frames and washers were constructed. The copper wires connecting the platinum leads to the fusible-metal caps were silver-soldered to the platinum, and for extra safety against possible strain the wires were screwed into the caps as well as hard soldered. In order to be protected as far as possible from unsymmetrical heating, which often gives rise to thermo-electric effects in certain types of thermometer, these joints between platinum and copper are arranged so as to be well inside the brass tube into which the glass or porcelain protection tube is fastened. The thermometer heads are of ebonite, and are of the design described by Harker and Chappuis in 'Phil. Trans.' 194, p. 52. They are practically airtight, and will stand vacuum or pressure for a considerable time. By a small tap, which is generally kept closed, communication can be made with a convenient apparatus for exhausting and letting in dry air while the thermometer is suitably heated. The effect of electric leakage in lowering the apparent resistance of a platinum thermometer when damp is much more easily traced on thermometers of 5 or 10 ohms FI than on the usual 1 ohm pattern used for high temperatures. With the thermometers here described, having the enclosed form of head, none of the determinations of fixed points have been found to be vitiated by moisture, care having been taken not to expose any portion of the interior to prolonged contact with the outside air, after once being thoroughly dried out at a high temperature.

The mica cross, having serrated edges with teeth of 1 mm. pitch, being attached to the leads and compensator, the joints between the 'bulb' wire are made in the strongly oxidising flame of a very small oxy-coal-gas blowpipe without admixture of foreign material of any description. Autogenous soldering of this kind is not very difficult, even for very fine wires, and is essential if the thermometers are intended for use to the highest temperatures safely measurable, namely, 1150° C., as the copper and silver contained in any solder which might be employed give off vapour sufficient to injuriously affect the platinum on prolonged exposure to a temperature considerably below this. The 'bulb' wire when fastened to the leads is then wound, not too tightly, upon the mica frame, and the thermometer is then inserted into its protecting tube of very thin glass or of porcelain, which must be glazed on the exterior, and if the thermometer is not intended for use above about 1000° C., may with advantage be glazed both inside and out. A measurement is then taken of the funda-

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mental interval, with a view to ascertain the change on annealing, which is then carried out by heating two or three times to about 1000° for several hours, with slow cooling, the thermometers with glass tubes being temporarily placed in porcelain ones for this purpose. The fundamental interval is then taken again, and if this is not considered sufficiently near the desired value, it can be lowered by cutting out the required amount from the looped end of the wire and re-fusing, or raised by stretching judiciously with platinum-tipped pliers the lowest few inches of the wire, which is unwound for the purpose. Care must be taken after each re-adjustment to remove any possible new strains introduced by a thorough re-anneal before measurement. In the absence of definite evidence in its favour, it was not deemed desirable for this first set of thermometers to heat the wire for some hours electrically to 1400° or 1500° C., as is usual in careful work with wires of platinum and the allied metals employed for thermo-junctions.

After the final adjustment of the FI and final anneal, systematic observations of the zero, steam, and sulphur points of the four thermometers were made from time to time with the resistance-box described in the text. A new calibration of the box-coils and bridge wire was made in February 1903, and the values of the relation $\frac{R_1}{R_0}$ and of the δ found since that date are tabulated for each thermometer. From this summary it will be seen that there appears to be a small but systematic difference between thermometers 1 and 3 on the one hand, and 2 and 4 on the other, this being noticeable both on the values of $\frac{R_1}{R_0}$ and of δ.

The values of $\frac{R_1}{R_0}$ vary from 1·38709 in BA_1 to 1·38881 in BA_3

the mean of the four being 1·38786, which is a little higher than the mean value found by Chree for the group of seven thermometers studied by him, namely, 1·38702.

The mean values of the δ are :

—	δ	Departure from Mean
BA_3	1·5124	+·0110
BA_1	1·5083	+·0069
BA_4	1·4935	−·0079
BA_2	1·4912	−·0192
Mean δ = . .	1·5014	—

The mean δ of the six thermometers observed in sulphur in Chree's experiments was 1·503, the maximum being 1·509 and the minimum 1·498. The mean values of the R_0, R_1, and FI for the period from February 12 to August 31 are also given. In view of the uncertainties in the measurement of the temperature of the box-coils, which are of platinum silver not immersed in a liquid, and also of small irregularities in the behaviour of the plug-contacts, the experiments afford no certain evidence of systematic change in any of the thermometers, unless it be a small rise in the fundamental coefficient and corresponding fall in the δ of BA_1.

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Thermometer BA_2, which was heated about fifty times during November 1902 in electric furnaces up to 1050°, and again during April and May 1903 to similar temperatures for prolonged periods, appears to be hardly perceptibly affected by it, no certain change of FI occurring during the period February 12 to August 18 covered by the later experiments, and certainly no variation of the zero of ·1° C.

To see if the small lack of homogeneity of the wire as shown by the properties of the different thermometers was due to the treatment it had received during the successive adjustments of FI, a new thermometer, named BA_7, was made up of wire taken from the inner end of the same reel as the other six. No attempt was made at adjustment of its FI, which was found after thorough annealing to be 100·022 box units.

The δ was found to be 1·506, an intermediate value. The wire was then unwound from the mica frame and suspended freely in air between the ends of the leads, and a current of $2\frac{1}{2}$ ampères, which was sufficient to maintain it at about 1400° C., was passed for about 2 hours.

Owing to the volatilisation of a considerable quantity of platinum from the wire, a large increase in the FI was found, as was expected, but the δ remained unchanged, though a rise in $\frac{R_1}{R_0}$ was recorded amounting to 1 part in 1000.

In order to make certain that the differences observed were not due to defective insulation in the thermometers, the insulation resistance between the thermometer and compensator leads of each of the thermometers was measured by a direct deflection method, and found to be in no case less than 700,000 ohms at any temperature between 0° and 1000° for BA_1 and BA_2, and 0° and 500° for BA_3 and BA_4. Some experiments were also made on an imitation platinum thermometer having its coil wound on mica of standard quality, but cut at the lower end into two parts.

Although the insulation from one part to another was practically infinite at all temperatures, when only platinum and mica were present in the heated part of the porcelain tube, the introduction of a small piece of clean copper wire into the hot space near the bulb was sufficient after some time to lower the insulation, even at only about 800° C., to a few thousand ohms. The cause of the differences between the individual thermometers does not, therefore, appear to be leakage.

Neither does the cause of the small differences in values of δ found lie in the method of taking the sulphur point, as the same apparatus was used in the same way for all the experiments. The sulphur is now boiled in an arrangement similar to Callendar and Griffiths's well-known pattern, except that, to avoid the necessity of removing the tube at each reheat after the sulphur has crystallised, the glass boiling-tube is replaced by one of thin weldless steel, brazed with spelter into a rather wider end-piece of thick iron tubing, which is exposed to the direct flame of the large bunsen used for heating. The level of the liquid sulphur is always maintained at least 2 inches above the bottom plate of the apparatus, and the upper level of the vapour to a definite position, which can be seen through mica windows in the upper part of the neck. Under these conditions no measurable superheating of the vapour has ever been observed, and a comparison of the sulphur points obtained with this form of apparatus with those got in the older one, with glass boiling-tube, reveals no measurable systematic difference.

For the boiling-point of sulphur under normal pressure in latitude 45′

Callendar and Griffiths's old value, 444°·53 C., has been retained, as was also the figure deduced by them from Regnault's experiments for $\frac{dt}{dp}$ for sulphur, namely, ·082° C. per mm., although it has been shown independently, by Chree and by Harker and Chappuis, that this value for the variation is considerably too small. It is hoped that a redetermination of this constant for pressures between 700 and 800 mm. will shortly be undertaken in the thermometric laboratory.

BA$_1$.

Date	δ	$\frac{R_1}{R_0}$	Difference of $\frac{R}{R_0}$ from Mean
Feb. 6, 1903	1·514	1·38688	−·00021
„ 23 „	1·505	1·38702	−·00007
Aug. 7 „	1·506	1·38708	−·00001
„ 25 „	1·505	1·38712	+·00003
„ 26 „	1·514	1·38722	+·00013
„ 31 „	1·506	1·38722	+·00013
	Mean 1·5083	1·38709	

Mean Value of Constants

R_0	R_1	FI	δ	$\frac{R_1}{R_0}$
257·905	357·736	99·831	1·5083	1·38709

BA$_2$.

Date	δ	$\frac{R_1}{R_0}$	Difference of $\frac{R}{R_0}$ from Mean
Feb. 12, 1903	1·484	1·38867	−·00014
„ 24 „	1·499	1·38877	−·00004
„ 24 „	1·495	1·38874	−·00007
May 19 „	—	1·38876	−·00005
July 30 „	1·497	1·38880	−·00001
Aug. 18 „	1·489	1·38863	−·00018
„ 21 „	—	1·38901	+·00020
„ 24 „	—	1·38890	+·00009
„ 24 „	1·493	1·38889	+·00008
„ 26 „	1·491	1·38892	+·00011
„ 31 „	1·489	1·38882	+·00001
	Mean 1·4912	1·38881	

Mean Value of Constants

R_0	R_1	FI	δ	$\frac{R_1}{R_0}$
257·172	357 163	99·991	1·4912	1·38881

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BA$_3$.

Date	δ	$\frac{R_1}{R_0}$	Difference of $\frac{R}{R_0}$ from Mean
Feb. 9, 1903	1·511	1·38740	+ ·00010
„ 26 „	1·511	1·38730	+ ·00000
Aug. 10 „	1·509	1·38714	− ·00016
„ 18 „	1·522	1·38732	+ ·00002
„ 24 „	1·511	1·38724	− ·00008
„ 25 „	1·515	1·38736	+ ·00006
„ 26 „	1·510	1·38731	+ ·00001
„ 31 „	1·510	1·38738	+ ·00008
	Mean 1·5124	1·38730	

Mean Value of Constants

R_0	R_1	FI	δ	$\frac{R_1}{R_0}$
258·367	358·434	100·067	1·5124	1·38730

BA$_4$.

Date	δ	$\frac{R_1}{R_0}$	Difference of $\frac{R}{R_0}$ from Mean
Feb. 11, 1903	1·485	1·38816	− ·00009
„ 23 „	1·499	1·38833	+ ·00008
„ 26 „	1·500	1·38826	+ ·00001
Aug. 10 „	1·497	1·38835	+ ·00010
„ 18 „	1·473 ?	—	—
„ 24 „	1·497	1·38825	+ ·00000
„ 26 „	1·494	1·38812	− ·00013
„ 31 „	1·503	1·38826	+ ·00001
	1·4935	1·38825	

Mean Value of Constants

R_0	R_1	FI	δ	$\frac{R_1}{R_0}$
257·627	357·616	99·989	1·4935	1·38825

BA$_7$.

R_0	R_1	FI	δ	$\frac{R_1}{R_0}$
257·749	357·771	100·022	1·506	1·38806
Thermometer electrically heated to 1400° for 2 hours				
270·036	375·213	105·177	1·506	1·38949

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APPENDIX IV

The following table gives the resistance at a temperature of 60° Fahr. (15°·55 C.) of a wire of pure annealed copper 1 metre in length, having a mass of 1 gramme, as deduced from the most recent determinations.

In making the reductions, the values for the temperature coefficient and for the density given by the author, have been used.

Table giving Resistance at 60 Fahr. of a Wire of Pure Annealed Copper, such that 1 metre weighs 1 gramme.

Authority	Source of Copper	Reference	Value in Ohm
Fitzpatrick . . .	Electrolytic	'B. A. Report,' 1890	0·1475
Swan and Rhodin .	Swan's Copper	'Proc. R. S.,' 1894	0·1493
Do. (Second sample)	" "	" "	0·1486
Fleming[1] . . .	Swan's Copper	'Phil. Mag.,' 1893	0·1487
Lagarde . . .	Grammont Electrolytic	'Hospitalier,' 1894	0·1488
		Mean value . .	0·1486

On the Use of Vectorial Methods in Physics.

By Professor O. HENRICI, *Ph.D., F.R.S.*

[Ordered by the General Committee to be printed *in extenso*.]

HAVING been engaged for over thirty years in teaching mathematics, chiefly to engineering students, I have always had much sympathy with them. They have to consider mathematics as a tool to help them in their work; abstract reasoning is in many cases a horror to them. At school they have most likely been treated as duffers, unable to learn mathematics; but if the subject is led up to through concrete examples, everything becomes alive and full of interest to them. It is for such men as these that I speak primarily, not for mathematicians. It is for them that I advocate the more general use of vectors and their introduction into the school curriculum; because vectors give the most natural mathematical expressions for many quantities in dynamics and physics, and their introduction helps in the study of these subjects and in obtaining clear views of the quantities dealt with.

The very invention of vectors is due to the needs of dynamics, and he who first represented a force by a directed line is their inventor. Who this was seems to be unknown; Newton was the first who clearly stated the 'Parallelogram of Forces.' Since his time vectors have always been used in dynamics, although the name 'vector' was only introduced by Hamilton.

That this representation of a force by a vector is natural no one will dispute, but only the addition of vectors (composition and decomposition of forces) was in use until Hamilton and Grassmann almost simultaneously,

[1] In reducing Professor Fleming's result, the density has been taken as 8·91 grammes per c.c.

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and from very different points of view, developed a calculus of vectors by defining their products. The applications of this new calculus to physics (including dynamics) remained long restricted to a few of their followers. It was, however, before their time that Faraday by his 'Lines of Force' and 'Fields of Forces' gave a purely geometrical representation of the phenomena of electricity and magnetism. Their analytical expression requires vectors. The first who recognised this was Clark Maxwell, and there can be little doubt that his success in putting Faraday's ideas into analytical form was greatly due to his knowledge of quaternions. His statements in the preface to, and in the preliminary chapter of, his 'Electricity and Magnetism' are in this respect of great interest. I quote from the latter: 'But for many purposes in physical reasoning, as distinguished from calculation, it is desirable to avoid explicitly introducing the Cartesian co-ordinates, and to fix the mind at once on a point of space instead of its three co-ordinates, and on the magnitude and direction of a force instead of its three components. This mode of contemplating geometrical and physical quantities is more primitive and more natural than the other, although the ideas connected with it did not receive their full development till Hamilton made the next great step in dealing with space by the invention of his calculus of quaternions.

'As the methods of Descartes are still the most familiar to students of science, and as they are really the most useful for purposes of calculation, we shall express all our results in the Cartesian form. I am convinced, however, that the introduction of the ideas, as distinguished from the operations and methods of quaternions, will be of great use to us in the study of all parts of our subject, and especially in electro-dynamics, where we have to deal with a number of physical quantities, the relations of which to each other can be expressed far more simply by a few words of Hamilton's than by the ordinary equations.'

He goes on: 'One of the most important features of Hamilton's method is the division of quantities of *scalars* and *vectors*.'

I have heard these words quoted as a proof that Maxwell was altogether in favour of Cartesian methods, and against quaternions and vectors. But this is wrong so far as vectors are concerned. In fact, the *ideas* which he took from Hamilton are chiefly two—*first*, vectors; and *second*, the classification of physical quantities into scalars and vectors. It is well known that he attached very great importance to the latter in connection with the theory of 'Dimensions.'[1]

This classification has been carried further by Clifford. Certain vector-quantities require position for their full specification; Clifford says such a quantity is 'localised,' and calls a localised vector a 'rotor.'[2] Forces, spins, momentum, are examples. There are also localised scalars like mass and energy.

In connection with this subject the enforced absence, due to ill-health, of Mr. Williams is much to be regretted. He has continued his valuable work of the Theory of Dimensions, and has lately taken 'position' into account. It was hoped that he would communicate some of his recently obtained results at this meeting, and thus bear witness to the importance of vectors in this direction.

[1] See his paper, 'Classification of Physical Quantities,' *Proc. Lond. Math. Soc.*, vol. iii. p. 224.

[2] Professor Joly has pointed out to me that Hamilton has also considered these. In his unpublished papers he calls them 'tractors.'

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With regard to vectors as entering into the study of the relations between physical quantities, Maxwell speaks against quaternionic *operations*, but he has no word against vectors. He never makes use of quaternions in his great work, but in the second volume constantly uses vectors, and gives at the end his final results in the form of vector equations.[1] In the passage quoted he states clearly why he uses Cartesian methods, and I cannot help thinking that he would have used vector methods throughout if he had found ready to hand a vector analysis instead of a theory of quaternions, and if such analysis had been common property.

At present every electrician expresses himself in terms of Faraday's lines of force; all elementary text-books use them, and by their aid the elements of electricity and magnetism have been made extremely simple. Theorems which formerly could be proved only by the aid of a considerable amount of analytical work are now proved in a few lines of reasoning, and often in a much more convincing manner. But when a certain point is reached there is an hiatus. The more advanced parts of the science are still only accessible by aid of the old methods of the differential or integral calculus, using co-ordinates of points and components of forces. These results are therefore inaccessible to all who have not been able to spend years on pure mathematics. Most physicists and electricians have neither inclination nor time to do this. To bridge over the hiatus and to introduce continuity in treatment requires vector analysis.

The subject itself is not difficult, and would become very easy if the first elements of vector algebra (which are very simple) were introduced into the school curriculum.

Vector addition is already known from the composition of forces. There come next two products of two vectors each—the scalar-product and the vector-product. The former is simple enough, as it follows all laws of common algebra with the exception of one which, although *the* law which distinguishes it from all other algebras, is generally not even mentioned in English text-books. It is the law that a product can vanish only if one factor vanishes. The second, the vector-product, requires more care in manipulation in so far as the commutative law does not hold. In addition to these, two products of three factors have to be considered, and the whole algebra is complete.

We have next to consider variable quantities. If u is a scalar-function of the position of a point, hence of the position-vector ρ, then $u = \text{const.}$ represents a surface which may be called a u-surface. If u is one-valued, through every point one such surface can in general be drawn. Thus space becomes filled with these surfaces, which are constantly used under the name of equipotential, isothermal, &c., surfaces. Similarly if η denotes a vector, varying from point to point, lines which may be called η lines are formed by drawing at any point the vector η, going along it through an infinitesimal distance, and drawing here the new vector. These are Faraday's lines of force in their purely geometrical aspect. They give the direction of η at every point, but not the magnitude. This Faraday introduced also in the well-known manner by drawing only some of these lines so that the number of the lines which cross a given area represents the magnitude of η.

[1] See also his little book *Matter and Motion*.

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If now $d\tau$ denotes an element of a surface, as a vector normal to the surface, then

$$\eta\, d\tau = (\eta\, d\tau)$$

gives the number of η-lines crossing the element and

$$\int \eta\, d\tau$$

extended over a finite area, the number which cross this area.

The differentiation of a vector with regard to a scalar, say, the time, is very simple and offers nothing new, although some results are striking. The variation of a function of ρ due to a displacement of the point or a change of ρ requires Hamilton's operator ∇.

This operator is of the nature of a vector and can operate on a scalar or a vector function, and on the latter in two ways. The three results thus obtained are of such physical importance that Maxwell has given them special names. From a scalar u we get the vector ∇u, which is a vector existing in general at every point where u exists and is normal to the u-surface through the point considered. Maxwell calls it the *slope of* u.

If the operand is a vector η the two results are, in Hamilton's notation with Maxwell's name,

$$\begin{aligned} \mathrm{S}\nabla\eta &= \text{convergence of } \eta, \\ \mathrm{V}\nabla\eta &= \text{curl } \eta. \end{aligned}$$

Instead of the former we have in vector analysis $(\nabla\eta) = \nabla\eta = -\mathrm{S}\nabla\eta$, which has been called by Clifford the divergence of η, is written by Heaviside Div. η. I have found it convenient to introduce for $\mathrm{V}\nabla$ or 'curl' a special symbol, a ∇ with an arrow-head rising from the top.

A ∇-calculus has been worked out in connection with quaternions by Tait, and recently by Professor Joly. The same can be done in vector analysis, and a good deal has been done (by Heaviside, Gibbs, and others). It deserves to be established as a purely mathematical theory.

Various applications, partly physical, partly relating to pure mathematics, were given at the meeting which are here omitted.

A few words about the teaching of vectors at school. My idea is that they should be introduced before trigonometry is begun, soon after, and in connection with the use of squared paper, by plotting points from given position-vectors, and curves from simple vector-equations.

The decomposition of a position-vector gives the co-ordinates of a point together with their *sense*, and then the equations

$$x = r\cos\theta, \qquad y = r\sin\theta$$

lead to general definitions of the trigonometrical functions holding for all four quadrants.

In the discussion which followed, and in which the President of the Section, Professor Bolzmann, Professor Larmor, Sir Oliver Lodge, Dr. Sumpner and others, and Professor Joly and Mr. Swinburne by letter, took part, no voice was raised against the extended use of vectors, but nearly everyone expressed the wish that an agreement should be come

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to about the notation used, and I have been asked to give a short account of those now in use.

Hamilton denotes vectors by small Greek letters. Maxwell changed these to German capitals, and Heaviside these again to *block* letters. Gibbs and likewise German authors use heavy type, the same letter in ordinary type standing for the tensors.

With regard to the notation of products greater divergency exists, and besides the scalar-product of Hamilton differs in sign from that of vector analysis. Keeping this in mind the following table will explain itself:—

Author	Name of Product	Symbol	Name of Product	Symbol
Hamilton	Scalar	$S\,\alpha\beta$	Vector	$V\,\alpha\beta$
Maxwell	„	$S\,\mathfrak{A}\mathfrak{B}$	„	$V\,\mathfrak{A}\mathfrak{B}$
Heaviside	„	**A B**	„	**V A B**
Henrici	„	$(\alpha\beta)=\alpha\beta$	„	$[\alpha\beta]$ or $[\mathbf{A}.\mathbf{B}]$
Lorentz	„	$\alpha\beta$	„	$[\alpha\beta]$
Grassman	Inneres	A | B	Aeusseres	A . B
Gibbs	Direct	**a . b** or **A . B**	Vector or skew	**a × b** or **A B**
Peano	Geometric	A × B	—	—

I have used brackets for years and found them convenient. I was led to them because I often found it confusing to decide at a glance how far Hamilton's symbols S and V extended, and had to introduce brackets to make this clear.[1] Professor Lorentz has adopted the same notation. Gibbs uses brackets [A B C] for the scalar-product of three vectors, which otherwise would appear as A . B × C.

There is a further product in quaternions which we may call the quaternion-product. Hamilton denotes it by $\alpha\,\beta$ with

$$\alpha\,\beta = S\,\alpha\beta + V\,\alpha\beta,$$

or, in my notation,

$$\alpha\,\beta = -(\alpha\beta) + [\alpha\,\beta].$$

This gives rise to a product $\alpha\,\beta\,\gamma$ for which the associative law holds, and is a chief point in the theory of quaternions, the product being a quaternion.

Professor Joly in his letter shows that the theory of quaternions can be based directly on this product by investigating the laws which make the associative law true for $\alpha\,\beta\,\gamma$.

In this way a quaternion becomes defined by the product of two vectors instead of by their quotient, and thus the theory of quaternions can be much simplified.

But if vector algebra has been studied independently of quaternions then anyone who still wishes to study the latter can do so at once by aid of the above equation as definition of $\alpha\,\beta$, which is a quaternion.

NOTE.—I learn from the January number of the 'Jahresbericht d. Deutsch. Mathematiker-Vereinigung' that on September 24, 1903, at

[1] Hankel must have felt the same, for he writes Hamilton's products thus: $S(ab)$, $V(ab)$, $V[aVbc]$, &c.

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the Naturforscherversammlung in Kassel, L. Prandtl in Hanover read a paper about a uniform notation in vector algebra. He recommends the notation of Gibbs.

A Committee was appointed to consider the whole question.

Meteorological Observations on Ben Nevis.—Report of the Committee, consisting of Lord M'LAREN, Professor A. CRUM BROWN (*Secretary*), Sir JOHN MURRAY, Professor COPELAND, *and* Dr. ALEXANDER BUCHAN. (*Drawn up by* Dr. BUCHAN.)

THE Committee was appointed as formerly for the purpose of co-operating with the Scottish Meteorological Society in making meteorological observations at the two Ben Nevis Observatories.

The hourly eye-observations have been made at the High Level Observatory by Mr. Rankin and his assistants, by day and night without interruption. At the Low Level Observatory in Fort William the self-registering instruments have been in continuous use throughout the year.

The health of the observers has been good. The Directors cordially thank Messrs. Robert Aitken, W. Gentle, and H. D. Robb for their valuable services as volunteer observers, thus rendering it possible to give the members of the regular staff vacation and rest during the summer.

The principal results of the observations made at the two Observatories during 1902 are detailed in Table I.

TABLE I.

1902	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Pressure in Inches.													
Ben Nevis Observatory	25·316	25·199	25·080	25·295	25·350	25·426	25·426	25·365	25·476	25·351	25·186	25·252	25·310
Fort William	29·959	29·841	29·650	29·894	29·958	29·924	29·945	29·863	29·990	29·904	29·752	29·874	29·879
Differences .	4·643	4·642	4·570	4·599	4·608	4·498	4·519	4·498	4·514	4·553	4·566	4·622	4·569
Mean Temperatures.													
Ben Nevis Observatory	24°0	22°1	25°8	27°1	27°6	39°6	37°7	37°9	38°6	32°3	29°9	26°0	30°7
Fort William	38·6	36·0	41·9	44·4	45·2	54·5	54·0	54·0	53·6	47·1	47·1	41·0	46·4
Differences .	14·6	13·9	16·1	17·3	17·6	14·9	16·3	16·1	15·0	14·8	17·2	15·0	15·7
Extremes of Temperature: Maxima.													
Ben Nevis Observatory	36·5	37·1	35·5	37·6	46·9	66·4	53·1	47·9	50·0	45·5	40·3	45·0	66·4
Fort William	51·0	52·3	51·0	61·6	59·4	80·0	66·9	65·4	67·9	58·7	59·6	55·2	80·0
Differences .	14·5	15·2	15·5	24·0	12·5	13·6	13·8	17·5	17·9	13·2	19·3	10·2	24·0
Extremes of Temperature: Minima.													
Ben Nevis Observatory	6·6	8·1	12·8	16·3	16·1	23·8	28·1	28·1	23·1	24·9	20·3	13·2	6·6
Fort William	12·4	14·9	26·2	28·0	30·6	39·9	41·5	41·2	36·1	31·2	35·6	24·4	12·4
Differences .	5·8	6·8	13·4	11·7	14·5	16·1	13·4	13·1	13·0	6·3	15·3	11·2	5·8
Rainfall in Inches.													
Ben Nevis Observatory	24·75	3·36	18·73	9·87	15·84	2·91	12·22	9·37	12·45	16·31	7·86	23·43	167·1
Fort William	10·03	1·07	7·58	3·38	4·63	1·62	3·65	4·95	5·49	9·05	3·73	9·14	64·6
Differences .	14·72	2·29	11·15	6·49	11·21	1·29	8·57	4·42	6·96	7·26	4·13	14·29	92·7

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TABLE I.—*continued.*

1902	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Number of Days 1 *in. or more fell.*													
Ben Nevis Observatory	12	0	7	2	2	0	2	2	4	6	3	9	49
Fort William	1	0	1	0	1	0	0	1	2	2	0	1	9
Differences .	11	0	6	2	1	0	2	1	2	4	3	8	40
Number of Days 0·01 *in. or more fell.*													
Ben Nevis Observatory	26	13	23	19	28	14	23	25	26	21	24	22	269
Fort William	24	14	29	20	22	14	19	22	22	20	21	21	248
Differences .	2	−1	−1	−1	6	0	4	3	4	1	3	1	21
Mean Rainband (*Scale* 0–8).													
Ben Nevis Observatory	2·2	1·3	0·8	2·1	2·9	2·3	3·5	2·0	2·1	2·7	2·8	2·1	2·2
Fort William	3·6	3·0	3·8	3·4	3·8	3·8	3·9	4·0	4·0	3·6	3·4	3·6	3·7
Differences .	1·4	1·7	3·0	1·3	0·9	1·5	0·4	2·0	1·9	0·9	0·6	1·5	1·5
Number of Hours of Bright Sunshine.													
Ben Nevis Observatory	31	64	29	82	45	131	55	34	40	50	19	21	601
Fort William	28	62	65	162	126	165	112	101	60	88	40	21	1,030
Differences .	+3	+2	36	80	81	34	57	67	20	38	21	0	429
Mean Hourly Velocity of Wind in Miles.													
Ben Nevis Observatory	13	19	13	16	10	11	9	8	12	14	28	20	14
Percentage of Cloud.													
Ben Nevis Observatory	85	77	92	76	93	76	92	93	86	82	92	94	86
Fort William	80	66	81	64	84	73	84	83	82	69	71	76	76
Differences .	5	11	11	12	9	3	8	10	4	13	21	18	10

The above table shows for 1902 the mean monthly and extreme temperature and pressure ; the amounts of rainfall ; the number of days of rainfall, and the days on which it equalled or exceeded 1 inch ; the hours of sunshine ; the mean rainband ; the mean velocity in miles per hour of the wind at the top of the mountain ; and the mean cloud amount. The mean barometric pressures at Fort William are reduced to 32° and sea-level ; but those at Ben Nevis Observatory to 32° only.

At Fort William the mean atmospheric pressure was 29·879 inches, or 0·022 inch above the average, whilst the mean at the top was 25·310 inches, or 0·004 inch above the average. The mean difference for the two Observatories was 4·569 inches, the mean monthly difference varying from 4·498 inches in June and August to 4·643 inches in January. At the top the absolutely highest pressure for the year was 26·258 inches at 11 P.M. on January 81, and at Fort William 31·103 inches an hour earlier on the same day. These are the highest barometric readings hitherto recorded at the Observatories, though they were closely approached in January 1896. They occurred while the British Isles lay under an anti-cyclone of extraordinary intensity, and on the top of the mountain the barometer remained above 26 inches from 6 P.M. on January 30 till 3 P.M. on February 2 ; whilst at Fort William the sea-level pressure exceeded 31 inches from 5 P.M. on January 31 till 1 P.M. on February 1. At the top, the lowest pressure for the year was 24·000 inches on December 29, and at Fort William 28·412 inches on the same day. The difference of the extremes at top and bottom were, therefore, 2·258 inches and 2·681 inches respectively.

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The deviations of the mean temperatures of the months from their averages are shown in Table II. :—

TABLE II.

	Fort William.	Top of Ben Nevis.		Fort William.	Top of Ben Nevis.
	°	°		°	°
January . .	−0·5	−0·2	July . .	−3·3	−3·3
February . .	−3·1	−1·5	August . .	−3·1	−2·7
March . .	+1·5	+1·8	September .	+0·3	+0·5
April . .	−0·6	−0·7	October . .	−0·5	+0·9
May . .	−4·7	−5·4	November .	+5·0	+0·9
June . .	−1·3	−0·2	December .	+1·0	+0·7

The most remarkable feature of the year as regards temperature was the continued deficiency from April to August. At both Observatories the mean temperature of May was only fractionally above that of April, whilst at the top the mean of the month was fully 10° below that of May 1901. The differences for November are curious. At Fort William, as over Scotland generally, the mean of the month was greatly above the average, whilst at the top there was a comparatively small excess, the main features of the weather there being a very low rainfall, little sunshine, and an atmosphere almost continuously saturated. The month was characterised by a great excess of strong winds from E. and S.E., and the weather was chiefly of the cyclonic type. The absolutely highest temperature for the year at Fort William was 80°·0 on June 29, and at the top 66°·4 on June 28 ; the lowest at Fort William being 12°·4 on January 30, and at the top 6°·6 on January 26.

In Table III. are given for each month the lowest observed hygrometric readings at the top of Ben Nevis (reduced by means of Glaisher's Tables) :—

TABLE III.

1902	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Dry Bulb . .	22·2	22·1	25·0	20·0	26·9	65·0	40·0	38·5	46·3	43·5	23·0	23·
Wet Bulb . .	16·1	16·1	17·0	16·0	23·0	50·0	32·3	33·5	33·0	35·5	19·8	17·0
Dew-point . .	-23·8	-23·3	-27·2	-12·4	5·1	37·7	22·3	26·8	18·4	25·9	-0·4	-20·8
Elastic Force .	·013	·014	·011	·024	·054	·226	·119	·146	·100	·140	·043	·016
Relative Humidity [Sat.=100]	11	11	8	22	37	36	48	62	32	49	35	13
Day of Month .	31	1	28	3	9	28	21	12	8	1	22	7
Hour of Day . .	17	1	1	10	5	16	10	24	10	10	1	16

Of these relative humidities, the lowest, 8 per cent., occurred on March 28, with a dew-point of −27°·2, that being the lowest dew-point for the year. The minimum humidity for August is unusually high. During that month the atmosphere was continuously saturated on fifteen days, rainfall and sunshine being both deficient. November was a remarkable month, from the 1st to the 13th and from the 23rd to the 30th being periods of uninterrupted saturation, whilst on only five days was the Observatory not continuously enveloped in mist.

The rainfall for the year at the top was 157·10 inches, or 0·57 inch below the mean of 18 years ; whilst the annual amount at Fort William was 64·32 inches, or 12·35 inches below the average for the same period. Thus, at the foot of the mountain, as over Scotland generally, the year

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was a very dry one, whilst at the top the amount of precipitation was practically equal to the average. The monthly amounts at the top, however, showed some notable irregularities. Thus January was a very wet month, with a rainfall about 8 inches above the mean, whilst the following month had a deficiency of about 9 inches, and was the second driest February on record. Again, the rainfall of May was more than twice the normal, being the largest total for that month during the series of observations; whilst, on the other hand, the rainfall for November was the smallest amount yet recorded for that month, being only a little more than half the average. At the top of the mountain, the greatest fall recorded in a single day was 5·92 inches on May 27, the corresponding fall at Fort William being 1·83 inch; whilst the maximum daily amount at Fort William was 1·99 inch, on January 19, the fall at the top on that day being 2·12 inches.

At the top of Ben Nevis the number of rainy days was 269, and at Fort William 248, the corresponding numbers for 1901 being 259 and 235. A feature of the weather of the year over the country generally was that, though the rainfall was much below the normal, there were more than the average number of rainy days. Thus, at Fort William the rainfall for the year was 16 per cent. below the normal, and yet there were 15 more than the average number of days of rain. At the top the number of rainy days was 8 above the average. In each of the months of February, March, and April, the number of rainy days was one more at the foot than at the top of the mountain, the greatest number of rainy days in a month at either station being 29 in March at Fort William, and the least, 13, in February on Ben Nevis. During the year the number of days on which 1 inch or more fell at the top was 49, whereas at Fort William the number of such days was only 9. The corresponding numbers for 1901 were 54 and 10.

The sunshine recorder on Ben Nevis registered 601 hours out of a possible of 4,473 hours, or 13·5 per cent. of the possible sunshine, being 146 hours below the average of 19 years. So little sunshine has not been recorded since 1890, when the annual amount was 590 hours. June was the sunniest month of the year, with 131 hours, being 4 more than the average and 25 per cent. of the possible. The amount for May was only 45 hours, being no less than 75 hours below the mean and the least recorded in that month since 1885. At Fort William the annual amount was 1,030 hours, being the smallest total in 12 years and 103 hours below the average for that period. May and November differed most from their averages, being respectively 40 and 48 hours below the normal for these months.

At the Ben Nevis Observatory the mean percentage of cloud was 86, and at Fort William 76, both a little above the average. At the top, May and August were the cloudiest months, each with 93 per cent. No month at either place had a very low cloud amount, whereas in May 1901 the amounts at top and bottom respectively were 56 and 52 per cent.

Auroras were observed on February 7; December 22, 23.

St. Elmo's Fire:—March 12; April 13; May 4, 5; October 30; December 25, 28.

Zodiacal Light:—Not observed during the year.

Thunder and Lightning:—June 25; December 28.

Lightning only:—January 3, 4.

Solar Halos:—February 18; March 16, 24; April 29 (with Mock Suns); May 10, 16, 21; July 21; September 19; October 12, 28.

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Lunar Halos :—January 20, 26, 27 ; February 17, 18 ; March 28 ; September 19 ; December 11, 14.

The question of the advisability of continuing the work at the Ben Nevis Observatories has lately been under consideration, and your Committee consider it advisable to state here briefly the past history of the Observatories and their present position, especially in relation to the value of the Observatories in forecasting weather.

The Meteorological Council, in 1887, when supplying information for a reply to a question put in the House of Commons about the Ben Nevis Observatory, stated that certain telegrams which had been sent from Ben Nevis Observatory at their request were useless for forecasting purposes. This statement was understood by the public to mean that the whole work at Ben Nevis Observatory was useless for forecasting. This view of the matter was corrected (1) in a letter to 'The Times' by Mr. Omond, and (2) in a Report to the meeting of the British Association from their Ben Nevis Committee in 1887.

The Low Level Observatory at Fort William, built by the Scottish Meteorological Society, and equipped with the necessary instruments by the Meteorological Council, was opened in July 1890. The full and complete equipment of this Low Level Observatory at Fort William by the Meteorological Council constitutes a feature of the first importance in the history of the two connected Observatories. During the period of the last thirteen years the High and Low Level Observatories have been in complete working order, furnishing in combination the simultaneous hourly observations which, in the opinion of your Committee, were essential in the inquiries instituted at these Observatories into weather changes and general meteorology.

As regards the seven years previous to 1890, when there were no hourly observations at the Low Level Observatory, what happened in relation to forecasting—that is, to efforts to use high level observations in forecasting—is told in the following extract from the Report of this Committee to the British Association in 1887 :—

Extract from Report of Ben Nevis Committee of British Association, 1887.

'On the evening of August 23, 1887, there was a discussion in Parliament on the Vote for the Learned Societies, and in that discussion the next-morning newspapers reported that Mr. Jackson, of the Treasury, Sir John Lubbock, Sir E. Birkbeck, and others, argued against any grant to the Observatory, on the ground that the Meteorological Council, composed of men of the very highest scientific standing, had given it as their opinion that the practical results to be obtained from the Ben Nevis Observatory did not warrant the grant asked for from the Treasury.

'A word as to this opinion. The Meteorological Council recently printed a memorandum "On Occasional Telegrams from Ben Nevis," signed Frederick Gaster, which was forwarded to the Treasury some time before the discussion came on in Parliament. A copy was also sent to the Directors of the Observatory by instructions from General Strachey. The memorandum concludes thus : "In their existing form the telegrams (from Ben Nevis) are absolutely useless."

'The whole question turns on the meaning of the phrase "their existing form," which a few sentences will explain.

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'When, in December 1883, the offer of the Directors to send daily telegrams from the top and bottom of the mountain was declined, the Meteorological Office asked instead for occasional telegrams in these words: "We wish Mr. Omond to use his own discretion, and telegraph to us whenever any very striking change of conditions or a special phenomenon of great interest is recorded." It will be noted that the Meteorological Office made no mention whatever of storms. Since December 1883 Mr. Omond has sent such telegrams as appeared to him to be wished, and no application has been made for upwards of three years for more frequent telegrams or any other information, only that some time ago a request was forwarded that every effort be made that the telegrams do not exceed the sixpenny charge.

'The request, it will be noticed, was for telegrams whenever any very striking change of conditions was recorded. Now, as a matter of fact, no telegram has been sent with reference to all those storms, forming the immense majority of storms, which have not been preceded or accompanied by a very striking change of conditions. But, further, several telegrams were sent because it seemed to Mr. Omond that the very striking change of conditions which occurred *prognosticated settled weather*. Now, in drawing up the memorandum for the Treasury all these, as well as the other telegrams sent, were classed together by the Meteorological Office, and treated as if they had been intended by Mr. Omond to be prognostic of storms, and the nineteen telegrams sent were assumed to be all the warnings of storms which the Observatory could send to the office in London. From these data, so arranged for and collected and interpreted, the decision was come to that "in their existing form the telegrams from Ben Nevis are absolutely useless." It might have been predicted before a single telegram was received that no other than such a decision could possibly have been arrived at.

'While the statement that "in their existing form the telegrams are absolutely useless" is thus unquestionably correct, it is, nevertheless, void of all meaning as respects the matter in hand. What has been done is not an investigation, and it is not science. But the statement underwent a transforming process in its passage to the House of Commons, appearing in this form, viz.: "The Ben Nevis observations are absolutely useless in forecasting weather"—a statement of which it is enough to say that it is incorrect. The Meteorological Office has yet to take the first step towards commencing an investigation into the utility of the Ben Nevis observations for forecasting purposes.

'On the other hand, the Council of the Scottish Meteorological Society, strengthened as regards the direction of the Observatory by representatives of the Royal Societies of London and Edinburgh and the Philosophical Society of Glasgow, includes men of equal scientific merit with any other Meteorological Council in the country; and after some years' investigation, their opinion is that the Ben Nevis observations are of the highest utility in the development of meteorology and in framing forecasts of storms and weather for the British islands.'

Since 1890, when the High and Low Observatories came into operation, no weather telegrams have been asked by or been sent to the Meteorological Council, either from the High or Low Level Observatories, for forecasting purposes. Further, so far as your Committee are aware, the Meteorological Council have, officially, neither expressed an opinion as to

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the value of these observations in forecasting, nor instituted any examination of the records of the Ben Nevis Observatories with the view of testing their possible value in forecasting.

As regards the future of the Observatories, it may be stated that last summer the Directors resolved that the two Observatories should be closed in October last year. They issued a memorandum which stated that the Observatory on the top of Ben Nevis had been in existence for nearly nineteen years, that it had been built, equipped, and very largely supported during the whole of that time by voluntary subscriptions, and that they considered the time had come when it should either be closed or continued as a State-supported institution.

Shortly after the publication of this memorandum, however, a Committee of Inquiry into the expenditure of the annual Parliamentary grant of 15,300*l.* for meteorology was appointed, and representations were made to the Directors from various quarters that it would be well if the work at the two Observatories was continued without interruption till the Committee had reported. Your Committee are, with much satisfaction, able to report that within a few weeks sufficient funds were obtained to meet the expenses incurred in maintaining the Ben Nevis and Fort William Observatories till October 1904. These Observatories will therefore continue in operation under the charge of the Directors as heretofore till October 1904.

The Observatories have thus been in operation long enough to yield, from a discussion of the work done at them, conclusions of great value. Their records supply a complete set of simultaneous hourly observations (1) at the summit of Ben Nevis for close on twenty years, and (2) at sea-level in Fort William for a period of thirteen years—times long enough to obtain averages of value and to embrace, it may be added, fully a sunspot period. The Directors have acquired these facts under conditions which are exceptionally favourable—the Observatory at sea-level being less than five miles distant in a straight line from the Observatory on the summit, and yet placed close to the sea and in a fairly open situation. Moreover, it is not a valley station. There are no other two associated Observatories or stations in the world, one at a high and the other at a low level, where such favourable conditions exist.

The geographical position of Ben Nevis is also favourable. In winter the British islands have a higher mean temperature than any other part of the land surface of the world equally far north, and consequently it is easier to live and work in winter at great altitudes in those islands than anywhere else in similar latitudes. All the other mountain stations are either in the Tropics or in the belt of high barometric pressure which occupies the southern part of the Temperate Zone. Ben Nevis, however, is clear of this high-pressure region, and lies on the edge of the great barometric depression in the North Atlantic which dominates the weather of North-Western Europe. From Ben Nevis, therefore, we get data of observation which no other high-level station yet established is in a position to furnish to forecasters of the weather of North-Western Europe.

The discussions of the double Ben Nevis and Fort William observations all go to confirm the opinion as to the value of these observations expressed by the Council of the Scottish Meteorological Society in 1887 and quoted in this report. Your Committee, however, desire to point out that the full value of the observations for forecasting purposes can only

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be tested by persons engaged in the practical work of forecasting day by day; your Committee or any other body of scientific men can only indicate the lines on which results of value in forecasting may be looked for.

The first work the Directors of the Observatories set themselves to do was to prepare the meteorological 'constants' for the positions on the summit and at the base of Ben Nevis. This has been done, based on twenty years' observations on the summit and thirteen years' at Fort William. The constants for these periods will appear in vol. iii. of the Ben Nevis observations, now in the press, and to be published during the coming winter.

In your Committee's previous Reports other lines of investigation have been frequently referred to and reported on, along which researches connected with the Ben Nevis observations are being carried on by Dr. Buchan and Mr. Omond. Some of the results have a special bearing on forecasting. One or two illustrative cases may be here added.

1. The occurrence of small differences of temperature between Ben Nevis and Fort William, associated with very low humidities at Ben Nevis and great dampness at Fort William, and the relations of this state of things to the stability and continuance of an anti-cyclone, and also to thunderstorms and those heavy local rains commonly denoted as thunder-showers, have been reported on.

2. The occurrence of long-continued periods of saturation of the air at the top of Ben Nevis, as indicative of a condition of the atmosphere favourable to the development and continuance of stormy weather.

3. A marked difference in the *direction* of the wind on the summit from that at surrounding low-level stations. Such a difference most commonly occurs when Ben Nevis lies between a cyclone and an anti-cyclone, and may be indicative of the direction of movement either of the cyclone or the anti-cyclone.

4. The predictive aspects of *very strong* winds on the summit of Ben Nevis accompanied, notwithstanding their great force, with very low temperatures there and great differences of temperature between the summit and Fort William, and the intimate connection of the whole with cyclonic weather, have been pointed out. Recent kite observations have made us tolerably familiar with this remarkable phase of the cyclone, and to Ben Nevis we may look for important contributions of illustrative data.

5. The difference between the Ben Nevis and Fort William barometers when both are reduced to sea-level. This difference, when it amounts to several hundredths of an inch, clearly points to an abnormal condition of the air between the summit and Fort William in respect to the vertical gradient of temperature or humidity, or both.

The investigation of some of the points raised in this discussion has been a chief subject of inquiry during the past eighteen months. The inquiry is a discussion of the hourly observations of pressure, temperature, humidity, sunshine, winds and rainfall at the two Observatories in their inter-relations, more especially as regards the bearings of the results on weather changes

The principal point to be kept in view is the relation of the differences of temperature at the two Observatories to the differences of their sea-level pressure at the time. An illustration will explain this. During the last three days of September 1895, the sky over Scotland was clear,

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sunshine strong, humidity high, night temperatures unusually high, and dews heavy, with calms or light winds. On these days while at the top temperature was very high and the air clear and very dry, at Fort William, under a sky equally clear and temperature high, the air showed a large humidity, and this state of moisture extended to a height of about 2,000 feet, or nearly halfway to the summit. Thus, then, while the barometer at the top was under an atmosphere wholly anti-cyclonic, with its accompanying dry dense air, the barometer at Fort William was not so circumstanced. On the other hand, it was under the pressure of such dry dense air, above the height of 2,000 feet only, whereas from this height down to sea-level it was under the pressure of air whose humidity was large and pressure therefore much reduced. The result was that the sea-level pressure at Fort William was 0·050 inch lower than it would have been if the dry dense air of the anti-cyclone had been continued down to Fort William. This is confirmatory of what is to be expected, that the greater density of dry air as shown in our laboratories prevails equally in the free atmosphere.

The first part of the discussion is virtually finished, the chief result of which is this :—1. When the difference of mean temperature of the day is only 12°·0 or less, then the sea-level pressure calculated for the top of the mountain is markedly greater than at Fort William ; 2. When the difference of temperature is 18°·0 or greater, then the sea-level pressure for the summit is markedly lower than at Fort William. In the former case the meteorological conditions are anti-cyclonic, the weather being then clear, dry, and practically rainless ; and in the latter case the conditions are cyclonic, the accompanying weather being dull, humid, and rainy. In the course of this discussion it has been marked that the reduced hourly values from day to day often indicate that the transition from the anti-cyclonic to the cyclonic type of weather, and *vice versa*, is slow, sometimes extending over several days, thus prolonging the time for the prediction of the more important weather changes.

It may be remarked that the result here empirically arrived at is in accordance with the principle laid down by Dalton, that 'air charged with vapour or vaporised air is specifically lighter than when without the vapour ; or, in other words, the more vapour any given quantity of atmospheric air has in it, the less is its specific gravity.'

The precursor and accompaniment of the heaviest and most widespread rains is when the sea-level pressure for the summit is very greatly lower than the sea-level pressure at Fort William. This indicates the saturation of the atmosphere to a great height, while at Fort William, and, say, 2,000 feet higher, the point of saturation due to the advancing cyclone has not yet taken place.

On the other hand, when this point of saturation has been reached, then the sea-level pressure for the summit shows less difference from the sea-level pressure at Fort William. The changes of pressure which occur at the two Observatories as a cyclone advances and passes on are particularly interesting and instructive.

It is remarkable that comparatively few observations, when the difference of the temperature has exceeded 22°·0, could be utilised in this inquiry, because in such cases high winds prevailed, resulting in 'pumping' of the barometer. These differences of temperature, rising even to 27°·0, are, however, extremely valuable for weather prediction, inasmuch as they often precede and accompany very severe storms of wind and rain. They arise from an extraordinary lowering of the temperature at the summit,

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while at Fort William no such lowering of temperature occurs. This is a peculiarity which kites and balloon ascents have recently familiarised us with, and it forms a prime factor in all inquiries into the theory of the cyclone, about which opinion at present is so much divided.

Report on the Theory of Point-groups.[1]—PART III.
By FRANCES HARDCASTLE, *Cambridge.*

§ 9. **1818–1857.** While Fermat and Descartes, by combining the processes of Algebra and Geometry, were evolving the foundations of that system of co-ordinates which rapidly became the common language of geometers, a contemporary mathematician, Desargues of Lyons (1593–1662), and his pupil Pascal (1623–1662) were occupied with the study of those properties of figures, in space and in the plane, which persist under the operation known as projection. And had it not been for the evil fate which caused the publications of both master and pupil to be lost, and for the oblivion into which even the memory of these writings sank for more than 180 years, it is probable that modern synthetic geometry would have been developed from the beginning side by side with analytical geometry, instead of coming into existence, as it did, a whole century and a half later than its rival. The fundamental characteristic of each—that which most distinguished both systems from the geometry of the ancients—is the same, the systematic use of the principle of projection. But it is noteworthy that, although this was present from the beginning in the structure of Cartesian co-ordinates (whereby every point of a curve is projected on to the axis), it was only after the rise of descriptive geometry under Monge (1746–1818) and Carnot (1753–1823) (who explicitly founded it upon projection from ordinary space on to the plane), that Plücker (1801–1868), by the use of homogeneous co-ordinates,[2] really opened up the projective possibilities inherent in analytical geometry. Throughout the period now to be discussed, the projective standpoint is the one adopted by analytical as well as by synthetic geometers; the transition to the wider point of view afforded by bi-rational transformation was only effected after the ideas of the theory of functions—at that time still in its infancy—had permeated the whole domain of pure mathematics, and had influenced the theory of higher plane curves to a degree which must have been startling to the mathematicians of the early nineteenth century.

Among the numerous novel terms introduced by Desargues in his 'Brouillon projet d'une atteinte aux événements des rencontres d'un cône avec un plan'[3] was that of involution,[4] and, unlike many of the others, it has survived. Starting from the definition that six points on a straight line are in involution if certain ratios can be established among the segments formed by them, Desargues proved his famous theorem that a conic and the sides of an inscribed quadrilateral determine six points in involution on any transversal. He did not, however, investigate the still

[1] Parts I. and II. appeared in the *Brit. Assoc. Reports* for 1900, 1902.

[2] Moebius's *Barycentrische Calcul* was printed in 1827, and was actually the first publication in which homogeneous co-ordinates were brought forward; Plücker's paper in *Crelle*, vol. v. (1830), gave the first exposition of trilinear co-ordinates. *Cf.* Clebsch, 'Julius Plücker zum Gedächtniss,' *Abhandlungen Göttingen*, vol. xvi. (1872), pp. 1–40.

[3] Discovered in De la Hire's manuscript copy by Chasles in 1845, and printed in Poudra, *Œuvres de Desargues* (Paris, 1864), vol. i. pp. 97–230.

[4] Poudra, *loc. cit.*, vol. i. p. 101, p. 109, p. 119; also vol. ii. p. 362.

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more significant fact that any conic through the four vertices of the quadrilateral cuts the transversal in a pair of points belonging to the same involution. This theorem was first published by Sturm [1] (1803–1835) in 1826; his proof is algebraical, being derived from the equations which, ten years previously,[2] had been shown by Lamé to be the necessary consequence of the simultaneous existence of three equations of the second order. He points out that the relations he thus obtains are those which establish 'cette liaison remarquable qui était nommée par Desargues involution de six points.' He afterwards mentions that the two pairs of opposite sides of a quadrilateral inscribed in a conic can be regarded as a pair of degenerate conics, and that Desargues's theorem is thus an immediate deduction from his own more general one; but he makes no statement which would lead us to suppose he saw the importance of considering what we now call a range of points in involution, viz. an infinite number of points on a straight line, such that if any two pairs are given the correspondent to a fifth point is determined by the relation called involution which holds for any six. Nor, again, is he really interested in the fact that a whole system of conics passes through the points common to two conics (although, of course, he is perfectly aware that a third conic through these points has an equation involving one linear parameter); his concern is with properties of the individual conic of the system, not with the system itself. And the same remark must be made about Lamé, although the idea of a pencil of curves is due to him [3]—that is to say, he found for the first time the equation, $E+mE'=0$,[4] of what we now call a pencil of curves; his primary interest was with the conditions which must subsist among the coefficients of the equations of three curves, in order that they may intersect in common points, and next, in the particular properties which follow for conics; with regard to curves of higher order, to which the greater interest, when looked at as a system, attaches itself, he simply stated the equation.

Gergonne (1771–1859) seems to have been the first to derive any property concerning the points of intersection of curves whose equation is of Lamé's form, as a direct consequence of this form. In 1827 he thus found [5] that *if* $p(p+q)$ *of the* $(p+q)^2$ *points of intersection of two curves of order* $(p+q)$ *lie on a curve of order* p, *the remaining* $q(p+q)$ *points lie on a curve of order* q: from which he obtained the corollary: *Given two systems of* m *lines in the plane, if among the* m^2 *points of intersection of the lines of one system with the lines of the other there are* 2m *which lie on a conic, then the* $m(m-2)$ *remaining points all lie on a curve of order* $(m-2)$. Writing $m=3$, this is, as he points out, the theorem known as Pascal's. This proof of Pascal's theorem also appears incidentally in a long footnote to the last chapter of the first volume of Plücker's 'Analytisch-geometrische Entwicklungen,' printed in 1828; the preface is dated September 1827, later than the publication of Gergonne's paper, and it is possible that this footnote was added at the same time; this would give the priority in discovery of this particular proof to Gergonne, as well as

[1] 'Mémoire sur les lignes du second ordre,' *Gergonne's Annales*, vol. xvii. pp. 173–198.

[2] 'Sur les intersections des lignes et des surfaces,' *Gerg. Ann.*, vol. vii. pp. 229–240.

[3] Clebsch, *loc. cit.*, p. 17.

[4] In his *Examen des différentes méthodes employées pour résoudre les problèmes de géometrie*, 1818, p. 29. See Part II. of this Report, § 8 (*Brit. Assoc. Report*, 1902).

[5] 'Recherches sur quelques lois générales qui régissent les lignes et surfaces algébriques de tous les ordres,' *Gerg. Ann.*, vol. xvii. (1827), pp. 214–252.

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the priority in publication which is undoubtedly his.[1] This, however, is a very small matter: Gergonne's contribution to the elucidation of problems connected with the intersections of curves is insignificant compared with Plücker's. It was Plücker who derived from Lamé's equation of a system of curves the theorem which threw fresh light upon the so-called Cramer Paradox, which had baffled mathematicians for more than a hundred years. And it was Plücker who, simultaneously with Jacobi (1804–1851), first ventured upon a line of research which afterwards proved a fruitful source of theorems in the theory of point-groups—the investigation, namely, of the conditions which must exist among the co-ordinates of certain points if they are known to be the points of intersection of two curves of given (differing) orders.

The problem which first led Plücker to consider the paradox was that of determining the highest degree of osculation possible between a curve of order n and one of order m. This question is treated in a footnote to an earlier chapter[2] of the work just mentioned, and its solution is made to depend upon the establishment of a new theorem, viz. that *all curves of the nth order, which pass through*[3] $((n))-2$ *given points intersect each other also in the same* $n^2-((n))+2=((n-3))$ *points*. In this passage the paradox is not explicitly mentioned; but in a paper published in the same year in Gergonne's Annales[4] Plücker speaks of it, describing it as the fact that in certain cases two curves of the same order may cut each other in at least as many points as are required to completely determine one of them. 'Cramer,' he continues, 'dans son "Introduction à l'analyse des courbes algébriques," est le premier, je crois, qui ait signalé cette espèce de paradoxe qui s'explique aisément en remarquant que, lorsqu'il est question du nombre des points nécessaires et suffisants sur un plan, pour déterminer complètement une courbe d'un degré déterminé, on sous-entend toujours que ces points sont pris au hasard, et ne sont liés entre eux par aucune relation particulière.' He establishes his new theorem in almost the same words here as in the other passage; the application is to the theory of the conjugate points of conics.

The second volume of the 'Analytisch-geometrische Entwicklungen' was published in 1832: in this Plücker returned to the subject of the paradox,[5] and remarked that Cramer had indicated the analytical explanation, viz. that the n^2 linear equations which correspond to the n^2 points of intersection of two curves of order n must, if $n>3$, be such that one or more, arbitrarily chosen from among them, are conditioned by those which remain; he adds that a geometrical interpretation of this explanation is needed. His own new theorem affords this geometrical interpretation, and he therefore reproduces it once more, with a proof which, when slightly elaborated, is substantially as follows:—

Assume $((n))-2$ arbitrary points in the plane, take any two curves of order n through them, $U=0$, $V=0$, which, in general, are completely determined if we know one more point, not the same, on each. Suppose

[1] See Kötter, 'Die Entwickelung der synthetischen Geometrie von Monge bis auf Staudt,' *Jahresber. d. deutsch. Math.-Verein.*, vol. v. (1901), p. 226. Clebsch (*loc. cit.*, p. 19) ascribes the priority to Plücker, without mentioning Gergonne.

[2] P. 228.

[3] $((n))$ is written throughout for $\frac{1}{2}(n+1)(n+2)$.

[4] 'Recherches sur les courbes algébriques de tous les degrés,' *Gerg. Ann.* vol. xix. (1828), pp. 97–106; also *Works* (Leipzig, 1895) pp. 76–82.

[5] P. 242.

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$U=0$, $V=0$ so determined, then $U+\lambda V=0$, where λ is an undetermined coefficient, is the equation of all those curves of order n which pass through the n^2 points of intersection of the above two curves. It requires one linear equation to determine λ, and thus the knowledge of any new point P on the locus $U+\lambda V=0$, but not on $U=0$ nor on $V=0$, is sufficient for this purpose, and the equation of the completely determined curve $U+\lambda_1 V=0$ which passes through an arbitrary point P can be obtained. Moreover, this same curve can also be uniquely determined by adding a point P to the $((n))-2$ arbitrary points (since $((n))-1$ points completely determine a curve of order n), and it passes through the n^2 points of intersection of $U=0$, $V=0$, *i.e.* through certain $n^2-((n))+2=((n-3))$ points common to $U=0$, $V=0$, as well as through the arbitrary points and P. Now take another curve $V'=0$ instead of $V=0$, and obtain in the same manner the equation $U+\mu_1 V'=0$ of a curve completely determined by the $((n))-2$ points, and the same point P as before; this curve is therefore identical with $U+\lambda_1 V=0$; and it passes through certain $((n-3))$ points common to $U=0$, $V'=0$. It has thus been shown that $U=0$, $V=0$, $U+\lambda_1 V=0$ all pass through certain $((n-3))$ points as well as through the arbitrary points, and also that $U=0$, $V'=0$, $U+\mu_1 V'=0$ all pass through certain $((n-3))$ points as well as through the arbitrary points; moreover, these points are in each case common to $U=0$ and to the particular curve determined by the addition of P to the arbitrary points, whose equation may be written either as $U+\lambda_1 V=0$ or as $U+\mu_1 V'=0$; that is to say, *they are the same* $((n-3))$ *fixed points*. By this argument it can be shown that any curve which passes through $((n))-2$ arbitrary points cuts any other curve through these points in the same $((n-3))$ fixed points.

The complete validity of this proof depends upon two assumptions: that every curve of order n through the points of intersection of two given curves $U=0$, $V=0$ of the same order has an equation of the form $U+\lambda V=0$; and that a curve of order n is completely determined by $((n))-1$ points. The first of these is a very special case of a much more general theorem [1] which, so long as the method of counting the constants of an equation was considered to afford a sufficiently rigorous proof of information obtained by its means, was supposed to be intuitively true. The difficulties of a rigorous proof of the general theorem, moreover, do not appear unless cases are considered in which the points of intersection are multiple points on $U=0$, $V=0$, and the minute investigation of higher singularities of curves had not yet been attempted; it is not surprising, therefore, that throughout Plücker's lifetime the theorem in question was taken for granted. With regard to the second assumption, the case is different; the paradox itself had arisen from a want of seeing exactly how the element of indetermination could enter into the equation of a curve drawn through $((n))-1$ points; and Plücker, in the above proof, expressly guards himself against exceptional cases by the use of the words 'arbitrary,' 'in general,' etc.

This had not, however, prevented Plücker from previously (in 1828) falling into a mistake which he afterwards corrected (in 1836). At the end of the footnote to the problem of osculation he had stated, namely, that the infinitely many curves of order n, $n>m$, through $((n-2))$ points

[1] Usually known as 'Noether's theorem.' See *Math. Ann.*, vol. ii. pp. 293–316 (1869) and *Math. Ann.*, vol. vi. pp. 351–359 (1872).

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on a curve of order m will all cut this curve again in the same $nm-((n))+2$ points. This is a fallacy, for since, by hypothesis, the $((n))-2$ arbitrary points lie on a curve of order m, which, since $((n))-2>((m))-1$ when $n>m$, would not have been possible in the original theorem without further conditions, it is now possible that the system of curves of order n should consist of degenerate curves, viz. the given curve of order m together with a system of curves of order $n-m$ which *all* pass through the additional arbitrary point, which point, therefore, taken in combination with the $((n))-2$ arbitrary points, fails to determine uniquely a curve of order n, and the line of argument adopted in the original theorem falls to the ground. (The correct statement in such a case is that the curves of order n all cut the curve of order m again in an *infinite* number of points.) But the exact number of arbitrary points which may be assumed upon the curve of order m without invalidating the previous line of argument can be found as follows: It is clear that, since $n>m$, the system will always contain certain degenerate curves, each of which consists of the given curve of order m, and some fixed curve of order $n-m$. Such a degenerate curve can play the part assigned to $U=0$ in the original theorem, and all the curves of order n through the $((n))-2$ arbitrary points must pass through $((n-3))$ additional points on it; it only remains to decide how the arbitrary points are distributed between the two curves of which it is composed, and what distribution of the additional points will then result. Now the conditions of the problem require the degenerate curve to be fixed, and this can only be effected by means of the assumption on the curve of order $n-m$ of a sufficient number of the arbitrary points to determine it completely, *i.e.* of $((n-m))-1$; the remaining arbitrary points which are $((n))-2-((n-m))+1$ in number, lie upon the given curve of order m; and the difference between nm and the last-named number, viz. $((m-3))$, is the number of additional fixed points in which all the curves of order n will cut the given curve of order m again.

Two equivalent algebraical statements of Plücker's original theorem are given in a paper which he published in Crelle's 'Journal' in 1836.[1]

(I.) *Si l'on donne à deux quantités variables successivement* $((n))-2$ *couples de valeurs quelconques, et si l'on suppose que ces valeurs satisfassent à une équation quelconque du* $n^{ième}$ *degré entre les deux variables, il y aura* $n^2-((n))-2=((n-3))$ *couples de valeurs nouveaux qui satisfont à la même équation et qui dépendent uniquement des couples précédents.*

(II.) *Si l'on connaît* $((n))-2$ *couples de racines de deux équations du* $n^{ième}$ *degré entre deux inconnues, l'on obtiendra les* $((n-3))$ *couples de racines restantes, sans avoir recours à ces équations.*

In the same paper the new theorem is also stated in algebraical form:

Si l'on connaît $nq-((q-3))$ *couples des racines de deux équations du* $n^{ième}$ *et du* $q^{ième}$ *degré entre deux inconnues,* n *étant plus grand que* q *et* q *plus grand que* 2, *l'on en déduira les* $((q-3))$ *couples des racines restantes sans recourir aux équations proposées, en fonction des racines connues et par la résolution de deux équations du* $((q-3))^{ième}$ *degré.*

It is established as follows:

Let $n=p+q$, and let $((p))-1$ of the $((n))-2$ couples of values which in the original theorem were all arbitrarily assumed, be now assumed to satisfy an equation $A_p=0$ of order p, which is then completely

[1] 'Théorèmes généraux concernant les équations d'un degré quelconque entre un nombre quelconque d'inconnues,' *Crelle*, vol. xvi. pp. 47–57; *Works*, pp. 323–333.

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determined. If the rest, which are $nq-((q-3))$ in number, satisfy an equation $C_q=0$ of order q, then, since $A_pC_q=0$ is one of the equations of order n satisfied by the $((n))-2=((p))-1+nq-((q-3))$ couples of values, it follows from the first algebraical statement of the original theorem that it will also be satisfied by $((n-3))=((q-3))+np-((p))+1$ other couples of values; but since every equation of order n has nq couples of values which are common to it and to $C_q=0$, it follows that the $nq-((q-3))$ above-mentioned couples of values which satisfy $C_q=0$ must lead to $((q-3))$ others, which also satisfy this equation of order q.

Plücker's final utterance on the intersections of plane curves occurs in the 'Introductory Considerations,' which form the first chapter of his 'Theorie der algebraischen Curven,' published in 1839. He there repeats the geometrical formulation of the original theorem, and also formulates the new theorem, geometrically, thus: *All curves of the* n*th order which pass through* nq−((q−3)) *points arbitrarily assumed on a given curve of order* q *cut this curve again in* ((q−3)) *more fixed points.* He further considers what possibilities exist for the distribution of the arbitrary points on two fixed curves of orders p and q respectively, where $p+q=n$, in order that all curves of order n through these arbitrary points may intersect each given curve again in a certain number of fixed points. These considerations lead him to state: *If of the* n^2 *points of intersection of two curves of order* n, nq−((q−3)) *lie on a curve of order* q, *then a curve of order* n−q *passes through the remaining* n(n−q) *points.* This, as he points out, is an improvement on Gergonne's theorem, inasmuch as it obtains the same result with a smaller number of assigned points. The closing paragraph of this chapter is devoted to historic considerations. In it Plücker refers to the passages in his former book, and to his papers in Gergonne's Annales, and once more draws attention to Cramer as the originator of the paradox.[1] He then goes on to explain that his paper in Crelle's Journal, although published in the sixteenth volume, was in the editor's hands at the same time as one of Jacobi's which appeared in the fifteenth volume. He adds that his own had been intended for the first volume of Liouville's Journal (which replaced Gergonne's Annales at about this date) and that 'a celebrated analyst had occasioned its preparation by a verbal observation about the difficulty of extending the relations which connect the roots of an equation in one variable to the case of the simultaneous roots of a system of two or more equations among two or more variables. . . . This is why it was written in French, and clothed in algebraic form.'

It was characteristic of Plücker's genius that he consciously limited the scope of his mathematical investigations to one particular domain—that of analytical geometry—within which, indeed, he found ample room for the employment of his rich imagination. This probably accounts for the fact that his writings on the intersections of curves are completely uninfluenced by the theory of functions, although his lifetime precisely covers the years in which this new branch of pure mathematics was being created. The account of the influence of the theory of functions on the theory of higher plane curves will fall into a later division of this Report, but it may be mentioned here that the interest which attaches itself to the paper of Jacobi's referred to by Plücker is partly due to its close

[1] For this point, *cf.* Part II. of this Report, § 6, last paragraph, *Brit. Assoc. Report*, 1902.

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connection with the algebraical theorem called by its author's name, a theorem which was afterwards destined to play an important part (at the hands of Clebsch) in the interpretation of Abel's theorem into the language of analytical geometry.

Jacobi's method is, in fact, the very reverse of Plücker's. The opening paragraph of this memoir,[1] after a brief reference to Euler's paper, 'Sur une contradiction apparente dans la doctrine des lignes courbes,'[2] and to the problem in the intersections of curves which is there dealt with, states that those problems are of *algebraical* importance, and that it appears advisable to investigate the equations of condition which exist among the values of two variables which cause two integral functions to vanish simultaneously. Throughout the course of this investigation the arguments are strictly algebraical, although a geometrical equivalent of each theorem is given. The following brief analysis of Jacobi's memoir will show wherein his geometrical theorems differ in enunciation from Plücker's, although dealing with the same problems.

The two integral functions which vanish by hypothesis for simultaneous values of the variable are, in the first place, to be of the same order n, and in order to arrive at the number of equations of condition which must exist among the values of the variables in this case, Jacobi begins by considering a function u of order n which vanishes for $((n))-2$ given systems of values. Since a function of order n contains $((n))$ coefficients (homogeneous), and since the given systems of values of the variables provide $((n))-2$ linear equations among the coefficients, it follows that u can be written in the form $a\Sigma a_{\alpha\beta}x^\alpha y^\beta + b\Sigma b_{\alpha\beta}x^\alpha y^\beta$, where a, b are the two coefficients which are not eliminated from the system of $((n))-2$ equations linear in the coefficients, and $a_{\alpha\beta}$, $b_{\alpha\beta}$ are the functions of the $((n))-2$ given values of the variables which, in solving for the other coefficients, are the multiples of a and b respectively, $\alpha+\beta$ taking all possible values from 0 to n. Any other function v of order n can similarly be written as $a'\Sigma a_{\alpha\beta}x^\alpha y^\beta + b'\Sigma b_{\alpha\beta}x^\alpha y^\beta$, where a , $b_{\alpha\beta}$ are the same functions as before. The common roots of $u=0$, $v=0$ are seen to be those of $\Sigma a_{\alpha\beta}x^\alpha y^\beta=0$, $\Sigma b_{\alpha\beta}x^\alpha y^\beta=0$ and are n^2 in number, $((n))-2$ of them are already known, therefore the remaining $((n-3))$ give rise to the $2((n-3))$ 'equations of condition' among the n^2 values of x and the n^2 corresponding values of y, which are obtained by substituting them successively in the two equations $\Sigma a_{\alpha\beta}x^\alpha y^\beta=0$, $\Sigma b_{\alpha\beta}x^\alpha y^\beta=0$. Hence the theorem :

Of the n^2 *systems of simultaneous values of* x *and* y *which satisfy two equations of the* n*th order in* x *and* y, $((n))-2$ *may be arbitrarily assumed and the remaining* $((n-3))$ *are determined by these; or, among the* n^2 *values of* x *and the* n^2 *corresponding values of* y *there are* $2((n-3))$ *equations of condition.*

The geometrical equivalent of this is :

Of the n^2 *points of intersection of two curves of order* n, $((n-3))$ *are determined by the rest.*

In the next section of his memoir Jacobi discusses the more complicated case in which the two integral functions are of differing orders, m, n. It is here that he makes use of certain $((m+n-3))$ equations upon

[1] 'De relationibus, quæ locum habere debent inter puncta intersectionis duarum curvarum . . . algebraicarum dati ordinis, simul cum enodatione paradoxi algebraici,' *Crelle*, vol. xv. pp. 285–308; *Works* (Berlin, 1884), vol. iii. pp. 327–354.

[2] *Acad. Berlin*, 1748, pp. 219–233; *cf.* § 8 of this Report (*Brit. Assoc. Report*, 1902).

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the existence of which he had based the theorem now known by his name, which he had published in the previous volume of Crelle's Journal.[1] These equations are the following, in which $x, \ldots x_{mn}$, $y, \ldots y_{mn}$, are the mn values of x, y which satisfy two given equations, $f(x, y)=0$, $\phi(x, y)=0$ of orders m, n, and R_k is the value of $\frac{\partial f}{\partial x}\cdot\frac{\partial \phi}{\partial y} - \frac{\partial f}{\partial y}\cdot\frac{\partial \phi}{\partial x}$ when $x=x_k$, $y=y_k$, $(k=1, \ldots mn)$.

$$
\begin{aligned}
&\sum \frac{1}{R_k}=0,\\
&\sum \frac{x_k}{R_k}=0, \sum \frac{y_k}{R_k}=0,\\
(A)\qquad &\sum \frac{x^2_k}{R_k}=0, \sum \frac{x_k y_k}{R_k}=0, \sum \frac{y^2_k}{R_k}=0,\\
&\cdots\cdots\cdots\cdots\\
&\sum \frac{x_k^{m+n-3}}{R_k}=0, \sum \frac{x_k^{m+n-4} y_k}{R_k}=0, \ldots \sum \frac{y_k^{m+n-3}}{R_k}=0.
\end{aligned}
$$

He first points out that if $m=n$, these equations are $((2n-3))$ in number, linear in $\frac{1}{R_k}$, $(k=1, \ldots n^2)$, from which by solving for $\frac{1}{R_k}$ from n^2-1 and substituting in the remaining $((2n-3))-n^2+1=2((n-3))$ equations we obtain this number of equations of condition among $x, \ldots x_{mn}$, $y, \ldots y_{mn}$, which is the same number as was previously obtained. But it must be noticed that nothing is said in either case about the conditions required to ensure the mutual independence of these $2((n-3))$ equations. Their number, in both places, is found by a 'method of counting constants,' and such a method affords no readily applicable means for dealing with special cases.

In the next case, in which $m \neq n$, Jacobi again finds the number of equations of condition by counting the constants in equations. The argument is briefly as follows :—An equation of order n (where $n<m$) is completely determined by $((n))-1$ systems of values of x, y, therefore there must be $mn-((n))+1$ equations of condition among mn pairs of quantities if, in accordance with a first hypothesis, mn pairs of values of x, y are to satisfy some particular equation of order n. In accordance with a second hypothesis, these mn pairs of values also satisfy some particular equation of order m. As a consequence of these two hypotheses, moreover, they can always satisfy any equation of order m formed of the sum of this particular one, and of the particular equation of order n multiplied by any arbitrary factor of order $m-n$; and such an equation of order m will only have $((m))-((m-n))$ arbitrary coefficients (homogeneous) in it, since $((m-n))$ can be destroyed by means of the coefficients of the arbitrary factor. Thus there must be an additional number $mn-((m))+((m-n))+1$ of equations of condition among the mn quantities, since this consequence of the two hypotheses must hold, after the first hypotheses has been satisfied. By addition, therefore, the total number of equations of condition among the $2mn$ quantities which satisfy two equations of orders m and n

[1] *Theoremata nova algebraica circa systema duarum æquationum inter duas variabiles propositarum.* Crelle, vol. xiv. pp. 281–288; *Works*, vol. iii. pp. 285–294.

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respectively, is $mn-((n))+1+mn-((m))+((m-n))+1=mn-3n+1$. This result is expressed geometrically thus :

In order that mn *points may lie on two algebraic curves of orders* m, n *it is necessary that* $mn-3n+1$ *equations of condition should subsist among their co-ordinates.*

And by comparison with a previous theorem we see that if $m=n$ the number of the equations of condition is increased by one.

A geometrical application of the above-mentioned consequence of the two hypotheses is :

If mn *points are taken on a given curve of order* n, $n<m$, *there must be* $mn-((m))+((m-n))+1=((n-3))$ *equations of condition among the co-ordinates of these points in order that these points may lie on a curve of order* m. Or in other words,

The maximum number of points which can be assumed on a curve of order n ($n<m$), *in order that a curve of order* m *may pass through them, is* $mn-((n-3))$, which (reversing n and m) is a slightly different version of Plücker's theorem, and is established by strictly algebraical reasoning.

Special instances of this theorem are :

If m *points are assumed on a straight line, or* 2m *points on a conic, it is possible to draw a curve of order* m *through them.*

If 3m *points are assumed on a cubic, where* $m>3$, *one equation of condition must hold among the co-ordinates of the points, in order that it may be possible to draw a curve of order* m *through them.* And so on.

When $m=n$ Jacobi obtained, as has been said, directly from equations (A) a system of $2((n-3))$ equations of condition among the $2n^2$ simultaneous roots of two equations of order n. When $m\neq n$ it becomes a much more complicated matter to actually obtain the corresponding $mn-3n+1$ equations of condition. The first step Jacobi makes towards this end is interesting, as it brings into consideration (although only in the special case of $r=m+n-3$) the question of the number of arbitrary constants in the equation of any curve of given order r through the points of intersection of two other given curves of orders m, n, a question which is of fundamental importance for the theory of point-groups.

Given two equations, $f(x, y)=0$, $\phi(x, y)=0$, of orders m, n, Jacobi takes, namely, any third equation of order $m+n-3$ such that it vanishes for the mn simultaneous pairs of values of x, y which satisfy $f=0, \phi=0$. Let this equation be denoted by $\Sigma p_{\alpha\beta} x^\alpha y^\beta=0$, $\alpha+\beta \leq m+n-3$, and obtain from it mn equations by substituting in it the values of the mn pairs of simultaneous roots ; multiply these equations in order by $\frac{1}{R_1} \ldots \frac{1}{R_{mn}}$ and add, the result is

$$\sum p_{\alpha\beta} \left(\frac{x^\alpha_1 y^\beta_1}{R_1} + \frac{x^\alpha_2 y^\beta_2}{R_2} + \ldots \frac{x_{mn} y^\beta_{mn}}{R_{mn}} \right) = 0,$$

which is the sum of all equations (A) multiplied respectively by $p_{\alpha\beta}$. This proves that one of equations (A) is a consequence of the remainder. But this is true for each and every linearly independent equation of order $m+n-3$, which can be formed in such a way as to be satisfied by the mn pairs of simultaneous roots ; and the number of these is equal to the number of arbitrary constants (homogeneous) in the equation of any one. But such an equation can be formed by multiplying the left-hand side of $f=0$ by an arbitrary function of degree $(n-3)$ and then adding it to the

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left-hand side of $\phi=0$ multiplied in its turn by an arbitrary function of degree $(m-3)$, and there are thus $((n-3))+((m-3))$ arbitrary constants (homogeneous) involved. It is thus seen that $((m-3))+((n-3))$ of equations (A) follow from the rest, and the number of independent equations is therefore $((m+n-3))-((m-3))-((n-3))=mn-1$. And since there are mn quantities $\frac{1}{R_k}$, they can be solved from these $mn-1$ equations, and the results in terms of the simultaneous roots can be substituted in the $((m-3))+((n-3))$ remaining equations, which are therefore the equations of condition among the $2mn$ simultaneous values of x and y. But since it is possible that $((m-3))+((n-3))$ may be $\geq 2mn$, it is clear, says Jacobi, that this number of equations of condition is too many; and he then proceeds to show that $((m-n-3))$ of these must follow from the rest, and that, therefore, the real number of independent equations of condition is, as he found before, $((m-3))+((n-3))-((m-n-3))=mn-3n+1$. Into this part of his discussion it is not worth while to enter here, as, once more, no criterion is established of the independence of the equations of condition when found in this manner.

The problem of determining the number of arbitrary constants at disposal (*i.e.*, non-homogeneous) in an equation of given order r, which is satisfied by the simultaneous roots of two other given equations of differing orders m, n—or, as it may be more shortly expressed, the problem of determining the degrees of freedom of a C_r—had been solved by Bézout (for any number of variables) as early as 1774; but the 'Théorie des équations algébriques,' which is devoted to the general problem of the elimination of variables from a system of simultaneous equations, appears to have fallen temporarily into oblivion, and is not referred to by any writer of this period. As far as the equations of curves are concerned, Plücker had only dealt with the case in which $r=m=n$, in which there is precisely one degree of freedom, as is at once apparent from the form of the equation $U+\lambda V=0$; for even the theorem which dealt with the intersections of a C_r and a C_m is based upon the discussion of a C_r through the points of intersection of two other C_rs, one of which is degenerate. In dealing with surfaces Plücker had come across the more general case, but he gave it at first a wrong solution. Jacobi, besides the more obvious case of $r=m=n$, had treated, as we have just seen, the case for curves in which $r=m+n-3$, and had shown that the degrees of freedom are then $((m-3))+((n-3))-1$. In the case of surfaces he also found the correct number, although the explicit problem before him there—as also before Plücker—was that of the number of equations of condition which must hold among the common points of three surfaces of degree m, n, r, and only intermediately that of determining the degrees of freedom of a surface through the curve of intersection of two others. When curves are concerned, the problem of determining the degrees of freedom of a curve through the intersections of two other curves and the problem of determining the number of equations of condition which must subsist among the co-ordinates of certain points in order that they may be the points of intersection of two curves of given orders are directly connected with one another, as will appear from an account of two papers by Cayley (1821–1895), which fall within the period under discussion.

The first of these, entitled 'On the Intersections of Curves,' appeared in 1843,[1] when its author was only twenty-two years of age. It is

[1] *Cambridge Mathematical Journal*, vol. iii. pp. 211–213; *Works*, vol. i. pp. 25–27.

short, but bears the unmistakable impress of that prolific genius which, upon the suggestion offered by any particular theorem, in no matter what branch of pure mathematics, at once sought its appropriate generalisation. In Chasles's 'Aperçu historique' (published in 1839) Cayley had come across that demonstration of Pascal's theorem which we have seen already employed by both Gergonne and Plücker. The demonstration of the property of cubics involved is, he says, 'one of extreme simplicity. Let $U=0$, $V=0$ be the equations of two curves of the third order, the curve of the same order which passes through eight of their points of intersection (which may be considered as eight perfectly arbitrary points), and a ninth arbitrary point will be perfectly determinate. Let $U_0=0$, $V_0=0$ be the values of U, V when the co-ordinates of this last point are written in the place of x, y. Then $UV_0-U_0V=0$ satisfies the above conditions, or it is the equation to the curve required; but it is an equation which is satisfied by all the nine points of intersection of the two curves, *i.e.*, any curve that passes through eight of these points of intersection passes also through the ninth.' He then generalises the form of equation used in the proof by forming $U\equiv u_{r-m}U_m+v_{r-n}V_n$, where u_{r-m}, v_{r-n} are two polynomials of orders $r-m$, $r-n$ with all their coefficients complete, and proceeds to consider how many arbitrary constants are at disposal in this equation. At first sight it would appear that there are $((r-m))+((r-n))-1$, this being the number of arbitrary constants in u_{r-m}, v_{r-n}, less one removed by division (and this was the erroneous conclusion arrived at by Plücker when dealing with surfaces in which $r>m+n$); but when we consider that, if $r>m+n$, we may take $u_{r-m}\equiv u_{r-m-n}V_n$, and $v_{r-n}\equiv -u_{r-m-n}U_m$, and that then $U\equiv 0$, we see that $((r-m-n))$ conditions exist among the arbitrary constants of u_{r-m}, v_{r-n} (viz. those obtained by equating to zero the coefficients of u_{r-m-n}), and that therefore there are only $((r-m))+((r-n))-1-((r-m-n))$ *independent* arbitrary constants at disposal. When $r=m+n-1$, or $m+n-2$, $((r-m-n))=0$, and it is therefore immaterial whether we consider these cases as subject to the law affecting the cases in which $r<m+n$, where they really belong, or under that of $r\geq m+n$; the simplest plan is to include them under the latter and to say that when $r>m+n-3$ the degrees of freedom of a C_r through the points of intersection of the given C_m, C_n are $((r-m))+((r-n))-1-((r-m-n))$; whereas if $r\leq m+n-3$ the degrees of freedom are $((r-m))+((r-n))-1$, which agrees with Jacobi's result for $r=m+n-3$.

The above statement which is substantially Cayley's own, deals only with the degrees of freedom of the C_r; but the question may also be put in other ways, for instance: How many conditions are imposed upon the coefficients of any C_r by constraining it to pass through the mn points of intersection of a given C_m and a given C_n? And: How many equations of condition must subsist among the co-ordinates of mn points on a given C_n if they are the points of intersection of the C_n with a C_m? Since, in general, a C_r has $((r))-1$ degrees of freedom, and since we have shown that, if $r>m+n-3$, a C_r under the given conditions has $((r-n))+((r-m))-1-((r-m-n))$ degrees of freedom, it follows that the number of conditions imposed by the mn points must be the difference between these numbers, *i.e.*, exactly mn; but if $r<m+n-3$, the degrees of freedom of the C_r were found to be $((r-m))-((r-n))-1$, and therefore the number of conditions imposed by the mn points on the constants of the C_r is, in that case, $((r))-1-((r-n))-((r-m))+1=mn-((r-m-n))$. Again,

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these results show that the number of equations of condition which must subsist among the co-ordinates of mn points on a given C_n in order that they may also lie on a given C_m are $((r-m-n))$, where r is the order of another curve through these mn points such that $r<m+n-3$. And this agrees with the theorems of Plücker and Jacobi. For if $r=m=n$, $r\leq 2r-3$, provided $r>2$, and $((r-m-n))=((-n))=((n-3))$; while if $r=m$, $m>n$, $r<r+n-3$, provided $n>2$, and once more $((r-m-n))=((-n))=((n-3))$.

Cayley, however, did not, in this paper, express his results in terms of the number of equations of condition; the problem he was generalising was geometrical, and in extending it he made the geometrical statement: *A curve of the* r*th order passing through the* mn *points of intersection of two curves of the* m*th and* n*th orders respectively, may be made to pass through* $((r))-1-mn+((r-m-n))$ *arbitrary points if* $r\leq m+n-3$; *if* r *be greater than this value, it may be made to pass through* $((r))-1-mn$ *points only.* And he concludes: '*Suppose* $r\leq m+n-3$, *and a curve of the* r*th order made to pass through* $((r))-1-mn+((r-m-n))$ *arbitrary points, and* $mn-((r-m-n))$ *of the* mn *points of intersection above. Such a curve passes through* $((r))-1$ *given points, and though the* $mn-((r-m-n))$ *are not perfectly arbitrary, there appears to be no reason why the relation between the positions of these points should be such as to prevent the curve from being completely determined by these conditions. But if this be so, then the curve must pass through the remaining* $((r-m-n))$ *points of intersection, or we have the theorem: If a curve of the* r*th order* ($r>m$ *or* n, $r\leq m+n-3$) *pass through* $mn-((r-m-n))$ *of the points of intersection of two curves of the* m*th and* n*th orders respectively, it passes through the remaining* $((r-m-n))$ *points of intersection.*'

More than forty years later (in 1886), this last theorem was challenged by a writer who had been influenced by Brill and Noether's work; the account of this discussion belongs to another section.

We have seen that Sturm in 1826 extended Desargues's theorem by showing that all conics through four points cut a transversal in pairs of points in involution. Since these conics have an equation of the form $U+\lambda V=0$, the obvious extension of the term involution is to the sets of n points determined on a straight line by the curves $U_n+\lambda V_n=0$ where U_n, V_n are of order n. Cayley, to whom the first suggestion of an extension of the term is due, went, however, much further than this in his new definition. In his paper entitled 'On the Theory of Involution in Geometry' published in 1847,[1] he thus defines the term: *If* U, V, . . . *be given functions of* x, y, z, . . ., *homogeneous of the degrees* m, n, . . ., *and* u, v, . . . *arbitrary functions of the degrees* r−m, r−n, . . ., *then if* $\Theta=uU+vV+\ldots$, Θ *is a function of degree* r, *which is in involution with* U, V, . . .; but, as a matter of fact the questions affecting such an equation as an involution are not discussed, and he at once states that *the question which immediately arises is to find the degree of generality of* Θ, *or the number of arbitrary constants which it contains.* It may be remarked here that the consideration of systems of curves whose equations involve *two* independent parameters, although such would come under the above general form for Θ by taking $\Theta=U+\lambda V+\mu W$, where U, V, W are of the same degree and involve

[1] *Camb. and Dublin Math Journ.*, vol. ii. pp. 52–61; *Works*, vol. i. pp. 259–266.

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two independent variables only, is foreign to Cayley's purpose, as it was to Plücker's and Jacobi's ; the only application of the results in which the additive combination of three functions is considered is to the equations of surfaces which involve *three* independent variables.

For our present purpose it will be sufficient to note very briefly the results of this paper so far as they apply to the case of two independent variables. A formula is, in the first place, found for the number of arbitrary constants in Θ, when any number of variables are involved, which is an extension of that found in the former paper for two independent variables, and the fact is pointed out, once again, that, for curves, when $r<m+n-3$, $((r-m-n))$ more arbitrary constants exist than would exist if Θ had passed through mn perfectly arbitrary points. The following general question is then attacked: *To find the number of relations which exist between* $K(\theta+1)$ *variables, forming* K *systems, each of which satisfies simultaneously equations of the orders* m, n, p, . . . *respectively; the number of these equations being anything less than* ϕ*; or* ϕ *being equal to* θ*, provided at the same time* $K=mnp$ . . . This question, as Cayley points out, is that solved by Jacobi for the particular case in which $K=mn$, $\phi=2$, $\theta=2$, the 'relations' being equivalent to Jacobi's 'equations of condition.' Cayley's general formula verifies Jacobi's result.

Seismological Investigations.—Eighth Report of the Committee, consisting of Professor J. W. JUDD (*Chairman*), Mr. J. MILNE (*Secretary*), Lord KELVIN, Professor T. G. BONNEY, Mr. C. V. BOYS, Professor G. H. DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Professor J. A. EWING, Dr. R. T. GLAZEBROOK, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, Mr. NELSON RICHARDSON, *and* Professor H. H. TURNER. (*Drawn up by the Secretary.*)

[PLATE I.]

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I. *General Notes on Stations and Registers.*

DURING the past year the registers issued are Circulars Nos. 6 and 7. These refer to Shide, Kew, Bidston, Edinburgh, Paisley, Toronto, Victoria (B.C.), San Fernando, Cairo, Cape of Good Hope, Calcutta, Bombay, Kodaikanal, Batavia, Baltimore, Mauritius, Trinidad, Irkutsk, Perth, Wellington, Christchurch, Cordova (Argentina), Honolulu, and Tokio.

Mr. F. A. Chaves, Director of the Meteorological Service in the Azores,

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writes that the two seismographs referred to in the Report for 1902 a now in working order, one at Ponta Delgada, 25° 41′ 15″ (1h. 42m. 45 W. long., and the other at Horta, 28° 38′ 26″ (1h. 54m. 34s.) W. long.

From Professor A. F. Griffiths, President of the Oahu College, Professor W. D. Alexander, also in Hawaii, I learn that the seismogr sent to Honolulu in 1899 is at the U.S. Magnetic Observatory near P Harbour. Mr. Weinrich, who has charge of the instrument, has insta it on a concrete pier rising from the bed rock. The instrument r measures 8 feet by 12 feet. It has stone walls 16 inches thick, and is li and ceiled with boards. The room has ventilators, but the temperat is almost uniform at 75° F.

Observers using or interested in the establishment of the Bri Association type of instruments who have during the past year visi Shide were Mr. W. J. Kenny, H.B.M. Consul, formerly of Haw Professor H. F. Reid, of Baltimore; Mr. C. Michie-Smith, of Kodaikan and Mr. E. Human, of Colombo. The latter gentleman, whose object to discuss observatory sites and the working of seismographs, came at suggestion of the Colonial Office.

As might be anticipated, now that experience has been gained working the instruments, correspondence with stations has considera decreased.

II. *The Origin of large Earthquakes recorded in* 1902 *and since* 1899.

On the accompanying map (Plate I.) the origins for 1902 are indicate by small numerals which correspond to earthquake numbers in the Shid registers. These are divided into districts marked alphabetically. The larg numerals give the number of large earthquakes which have originated i each district since 1899. Maps corresponding to the one here given ca be found in the 'British Association Reports' for 1900, p. 70, and 1902 p. 64. The methods employed in determining origins are referred to in the Report for 1900, pp. 79 and 80.

The chief feature in the map for 1902 as compared with those for preceding years is the increase of activity shown for the Caucasian-Himalayan district K and the decrease in the Alaskan and Andean regions (A and D). If we omit districts E and A then, as pointed out by Professor Libbey, a circle of about 70° radius and centre 180° E. or W. long. and 60° N. latitude in Behring Straits passes through the seismic regions of the world which are at the present time most active. On the map this is indicated by a dotted line. The Pacific origins fall on a circle about 75° in radius, with its centre 180° E. or W. long. and 30° S. lat.

Mr. J. H. Jeans, in his paper on 'The Vibrations and Stability of a Gravitating Planet,'[1] suggests that these regions lie on a great circle of which England is the pole, this circle being the equator of the supposed pear-shaped form of the world. The equator for the pear-shaped form, according to Professor W. J. Sollas,[2] has its centre about 6° N. lat. and 30° E. long.

III. *Earthquakes and Changes in Latitude.*

In the 'British Association Report' for the year 1900, p. 107, the wanderings of the pole from its mean position are compared for the years

[1] *Phil. Trans. Royal Soc.*, vol. cci. p. 183.

[2] 'The Figure of the Earth,' *Quart. Journ. Geol. Soc.*, vol. lix. Part 2.

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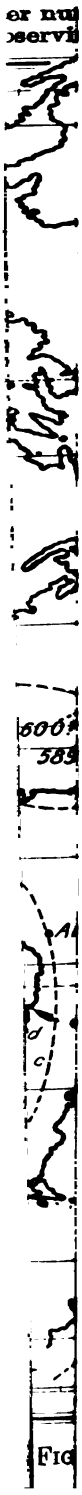

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1895 to 1898 inclusive, with the registers of earthquakes which during that period have disturbed the whole world, or, at least, continental areas. A suggested conclusion was that when the pole displacements were comparatively great large earthquakes were frequent, and *vice versa*. The inference to be drawn from the following note is that this same type of earthquake has been frequent when the change in direction of the movement of the pole has been marked. In the following table the years (1892 to 1899) have each been divided into ten parts, and the large earthquakes which occurred during each of these intervals are given by numerals.

The earthquake registers from which the latter figures have been abstracted are as follows :—

1. March 14, 1892 to Aug. 7, 1893.—Strassburg and Nicolaiew (see 'Horizontalpendel-Beobachtungen,' &c., von Dr. E. von Rebeur-Paschwitz. 'Beiträge zur Geophysik,' Band II.).
2. Aug. 7, 1893, to Sept. 12, 1834.—Charkow (see 'Ergebnisse der auf der Charkower Universitätssteinwarte,' mit den v. Rebeur'schen Horizontalpendel angestellten Beobachtungen, v. Prof. G. Lewitzky).
3. Jan. 1, 1894, to Dec. 31, 1896.—Italian and other stations (see 'Bollettino della Società Sismologica Italiana,' 1895.
4. Jan. 1, 1897, to Dec. 31, 1902.—Registers from stations widely spread over the world, published by the Seismological Investigation Committee of the British Association.

Although these registers are comparable so far as world-shaking earthquakes are concerned, it is evident that in the last list very large earthquakes are included which could not have reached stations in Europe. For this reason, so far as actual frequency is concerned, Registers I., II., and III. are not comparable with No. IV.

Periods	1892	1893	1894	1895	1896	1897	1898	1899
0–1, Jan. 1 to Feb. 5 .	no obs.	8	12	1	2	3	4	9
1–2, Feb. 5 to Mar. 14 .	„	22	11	1	1	7	4	9
2–3, Mar. 14 to April 19	14	16	13	1	1	3	8	10
3–4, April 19 to May 26	8	32	19	0	4	5 or 7	5	4
4–5, May 26 to July 1 .	0	41	3	1	3	7 or 11	8	6
5–6, July 1 to Aug. 7 .	8	24	14	1	0	5	7	16
6–7, Aug. 7 to Sept. 12	8	20	10	2	3	9	5	6
7–8, Sept. 12 to Oct. 19	12	12	no obs.	0	5	10	6	10
8–9, Oct. 19 to Nov. 24	7	6	„	2	5	7	1	7
9–10, Nov. 24 to Dec. 31	10	9	„	1	0	5	5	5

Earthquake figures connected by brackets refer to two periods, each of 36·5 days, when the change in direction of pole movement was marked. In the following table the total number of earthquakes which occurred in each of these two periods is so far as possible compared with the total number of earthquakes which were recorded in equal intervals of time (73 days) before and after the deflection periods.

Earthquakes before deflection :	no obs.	8	38	18	—	22	no obs.	1	3	3
Earthquakes during deflection :	*22*	*20*	*73*	*21*	24	*24*	2	*3*	*2*	*10*
Earthquakes after deflection :	8	17	44	—	22	no obs.	1	2	7	3

Earthquakes before deflection :	3	14	8	15	14	10
Earthquakes during deflection :	10	17	13	11	*19*	*22*
Earthquakes after deflection :	12 or 18	9	15	6	10	17

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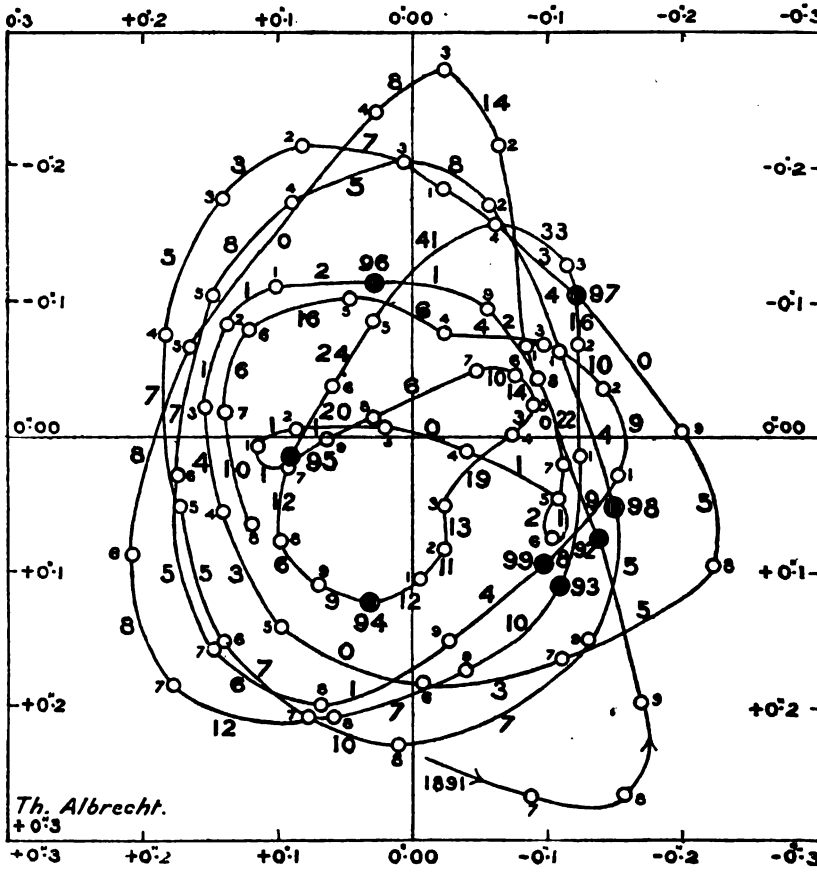
Out of sixteen deflections there are twelve instances where the greater number of earthquakes have taken place during the deflection period. In three instances the number for the deflection period, although exceeded by number before or after that period, has been greater than the average of the sum of the preceding and succeeding numbers. In only one instance (February 5 to April 19, 1896) have the earthquakes in the deflection period had a distinct minimum. The totals for before,

FIG. 2.



during, and after comparable deflection periods are respectively 117, 200, and 153.

One inference from this investigation is not that the molar displacements accompanying large earthquakes result in polar displacements, but rather that changes in direction of these latter movements, particularly when the rate of change has been rapid, have had an influence upon earthquake frequency. From Albrecht's figure of movements of the North Pole (fig. 2), on which the numbers of large earthquakes corresponding to different periods are given, the periods of rapid change can be seen.

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IV. *On the Comparison of Records from three Milne Horizontal Pendulums at Shide.*

At Shide three Milne horizontal pendulums are installed on two similar brick piers, 2 ft. 6 in. distant from each other. Each pier is 1 ft. 6 in. square, and rises 4 feet above its footings, which rest on concrete. One pier was built in May 1897, and the other in November 1902. The instruments are described in the 'British Association Report' for 1902, p. 60. The older of the two piers carries the type instrument, which has a period of 16 seconds and records east and west movements. This is referred to as pendulum A. Pendulum B has the same period, and is oriented in the same direction as pendulum A. Pendulum C, which with B forms the Yarrow instrument, has a period of 20 seconds and records north-south motion.

The following results refer to seismograms obtained between November 21, 1902, and March 24, 1903, or in the Shide register Nos. 659 to 693.

Times of Commencement.—Out of twenty-six cases the times of commencement of A and B have in eleven instances never differed more than one minute. When this limit has been exceeded the movements to be measured have usually been slight thickenings or blurs. Comparing C with A or B, out of nineteen cases there are ten instances falling within the one-minute limit.

Times of Maxima.—The times at which maxima have occurred as recorded by A and B have not differed more than two minutes in ten instances out of fourteen records. When this limit has been exceeded the records usually refer to slight thickenings in traces in which one out of several points might be selected as a maximum.

The maxima for C agree within the two-minute limit with those of A and B eight times.

Amplitudes.—The amplitudes recorded by A and B have in twenty-five cases only once differed 1 mm. from each other. The records obtained for C have not differed greatly (·5 to 1·5 mm.) from those shown by A and B. Out of twenty instances the C records were eleven times larger, three times smaller, and nine times equal to those shown by A and B.

Durations.—Out of twenty-one instances the records of C were three times greater, six times smaller, and twelve times practically equal to those obtained from A and B.

These comparisons are similar to comparisons of records from two similar seismographs made by Dr. Charles Chree, F.R.S., at Kew.[1]

V. *On the Comparison of Earthquake Registers from Shide, Kew, Bidston, and Edinburgh.*

In the 'British Association Reports,' 1901, pp. 44–50, and 1902, pp. 73, 74, references are made to series of earthquake records obtained at Kew, Shide, Bidston, and Edinburgh, stations which are respectively situated on alluvium, chalk, sandstone, and volcanic rock.

The following notes chiefly refer to observations made between July 1 and December 31, 1902, during which period the instruments at the different stations have been so adjusted that 1 mm. deflection of the outer end of the boom corresponded to a tilt of the bed plate of 0″·5.

[1] See *B.A. Report*, 1901, p. 51.

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Earthquake Frequency.—The number of earthquakes recorded were as follows :—

July to December, 1902 .	Bidston,	69	Shide,	40	Edinburgh,	37	Kew, 30
During the year 1902 .	„	134	„	78	„	70	„ 64
During 11 months in 1901 .	„	94	„	90	„	85	„ 63
Total for two years		228		168		155	127

Each of the earthquakes considered was recorded at more than one station, and therefore it is extremely unlikely that artificially produced disturbances have been included in the computations.

Earthquake Duration.—Between July and December there were ten earthquakes, each of which was recorded at all four stations. The total number of minutes which the instruments were caused to move by these disturbances were :—Edinburgh, 691 ; Kew, 610 ; Shide, 606 ; and Bidston, 545.

Amplitudes —The sum of the maximum amplitudes in millimetres for ten earthquakes was as follows :—Shide, 19·4 ; Kew, 14·1 ; Edinburgh, 12·0 ; Bidston, 9·0.

These quantities regarded as angular displacements may be respectively read as 9″·7, 7″·2, 6″·5, and 4″·5. Add to these the corresponding quantities for earthquakes recorded between January and June, then the totals for the year 1902 are : Edinburgh, 21″·5 ; Shide, 21″·1 ; Kew, 20″·9 ; and Bidston, 13″·2.

If in making these comparisons the large earthquakes are omitted, then the amplitudes of motion as recorded at different stations are practically identical.

Commencements.—Out of thirteen records (June to December 1902) at Bidston the commencements have been the earliest—or not more than two minutes later than those recorded at other stations—nine times, at Shide seven times, at Edinburgh six times, and at Kew three times.

Conclusion.—For the present, at least, the conclusions arrived at are as follows :—

1. Bidston records the greater number of earthquakes and obtains earlier commencements for the preliminary tremors more frequently than at other stations.

The durations and amplitudes recorded at Bidston are less than at other stations.

2. Kew records the least number of disturbances, and commencements are frequently late. Durations and amplitudes are similar to those obtaining at Shide.

3. At Edinburgh and Shide, frequency, time of commencement, and amplitude are similar, but at the former station the duration is greater than at the latter.

VI. *Earthquake Commencements as recorded at Strassburg and in Britain.*

The records referred to in the following note are those obtained in 1902 from the Rebeur-Ehlert pendulums at Strassburg or Hamburg[1] and the Milne pendulums installed at Kew, Shide, Bidston, and Edinburgh. The multiplication of the Strassburg apparatus is about eight

[1] See *B.A. Report*, 1898, p. 268.

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times that of the instruments employed at the stations in Britain, from which it might be inferred that very minute preliminary tremors might be recorded, and therefore earlier commencements of motion be calculated for these Continental stations than would obtain in Britain.

With the assumption that the greatest difference in time that could exist between the commencement of motion at these two groups of stations is four minutes, the comparison of fifty-six records common to Germany and Britain leads to the following :—

In twenty-four instances the difference in the times of commencements does not exceed the four-minute limit. These in the Shide register correspond to numbers 581, 584, 585, 586, 588, 590, 595, 606, 614, 616, 619, 619*b*, 625, 627, 636, 641, 642*c*, 644, 653, 658, 661, 662, 663, 665.

The remaining thirty-two instances where this limit has been exceeded refer to twenty-one mere thickenings of the trace and eleven to earthquakes with moderate amplitudes. These thirty-two instances may be divided into two groups, there being twenty-three cases where the British records are late relatively to those noted in Germany, and nine when the German records fall behind those obtained in Britain. The British records, which are late, are numbers 578, 580, 583, 597, 598, 600, 600*b*, 606*b*, 611, 613*b*, 617, 618, 622*b*, 624, 633, 639, 640, which are all minute thickenings on the trace, and 589, 592, 599, 609, 612, and 659, which are well-defined records.

The German records, which are late, are numbers 576, 582, 610, which, as noted in Britain, are small, and numbers 572, 593, 601*c*, 607, 626, 642, which are large or fairly large disturbances. The number of disturbances as recorded in Germany with too late commencements, oddly enough, is exactly the same as recorded in Britain.

The conclusions to which these comparisons point are :—

1. For recording small tremors which do not extend over great areas the Rebeur-Ehlert pendulum, as installed at Strassburg, possesses advantages over the Milne horizontal pendulum as installed at stations co-operating with the British Association.
2. For recording the commencements and, it may be added, other phases of earthquake motion which affect the world as a whole the accuracy of the records from both types of instruments is practically identical.

In connection with these conclusions it must be pointed out the fineness of the trace obtainable with the British Association type of instrument partly compensates for its comparative want of sensibility. The particular sensibility given to it is one that is obtainable at a variety of stations. Were this increased, which is easily done by raising its period from sixteen to twenty, or even forty, seconds, when it would be more responsive to tremors, then at many stations it would be found that diurnal and other wanderings, together with air tremors, would seriously interfere with the recording of earthquakes. Instruments of the Rebeur-Ehlert type, with large multiplication, not only consume what for many would be a prohibitive quantity of photographic paper, but, as for example at Trieste and Kremsmünster, they are frequently recording movements which are not required.

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VII. *The Velocity of Propagation of Earthquake Vibrations.*

In the 'British Association Report' for 1902, p. 65, a diagram is given showing the time taken for various phases of earthquake motion to traverse arcs or distances corresponding to arcs of various lengths.

From this diagram an arcual velocity for the maximum of large wave movement may be derived of 3 km. per second. For the commencement of such movements this would be slightly increased, and would then accord with observations made by Dr. F. Ōmori, who obtains for this particular phase an arcual velocity of 3·3 km. per second.

To give actual velocities or average velocities for the preliminary tremors, not knowing the paths they follow, is accompanied by uncertainties. What can be done, and is shown in the following table, is from the above-mentioned time curve to calculate velocities on the assumption that the paths have been arcs or have approximated to chords, or we can make similar calculations from a time curve so corrected that 11 and 17 minutes are respectively taken to traverse distances corresponding to 70° and 150°. The justification of reducing the steepness of the preliminary tremor curve and yet keeping within the results of observation rests upon the analysis given on pp. 5 and 6.

Average Velocities of Preliminary Tremors.

—	10°	20°	30°	40°	50°	60°	80°	90°	150°	—
Uncorrected time curve on arcs.	3 to 5	9·2	9·2	9·2	9·2	9·6	9·8	10·1	12·9	Km. per second.
Uncorrected time curve on chords.	3 to 5	9·2	9·1	9·1	9·0	9·2	9·1	9·1	9·4	„ „ [1]
Corrected time curve on arcs.	3 to 5	10·5	11·1	10·6	10·9	11·1	12·3	12·8	16·3	„ „
Corrected time curve on chords.	3 to 5	10·5	10·9	10·3	10 5	10·6	11·3	11·5	12·0	„ „ [2]

From the above table it will be seen that if the preliminary tremors follow paths which are arcual, then there is a marked increase in speed of transmission on long paths as compared with the speed upon short paths. If, however, the paths approximate to chords, then velocities which are approximately constant prevail. The deviation from being actually constant along chordal paths is apparently a slight increase in speed along paths taken nearer and nearer to the centre of the earth.

The high values of 10·5 to 12 km. per second suggest a high rigidity for the world, whilst the approximate uniformity of speed within its core indicate approximate uniformity in those properties which determine the rate at which it transmits vibrations. Unless it is assumed that as we descend in the earth electricity and density increase in the same ratio, to which hypothesis there are objections, the inference is that the nucleus of the world has a density more nearly uniform than is generally assumed.

To satisfy the interpretation given to these seismometrical observations what is required is a globe with an approximately uniform nucleus not less than $\frac{10}{9}$ of the earth's radius covered by a shell which passes rapidly upwards into the materials which constitute the crust of the world.

[1] In an article in *Nature*, April 9, 1903, p. 538, on 'Seismometry and Geite,' *minimum* values are given for these quantities.

[2] If these last values are plotted on squared paper a curve for their mean position gives the following values: 3 to 5, 9·0, 10·4, 10·6, 10·8, 11·0, 11·3, 11·5 and 12·0 km. per second.

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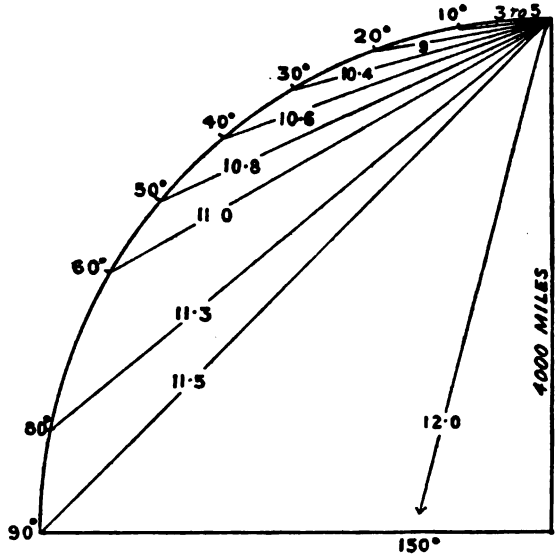
That low velocities are found on wave paths corresponding to chords of less than 10° suggests that this crust is not more than forty miles in thickness. This seismometrical determination of thickness for the earth's crust accords, it will be observed, with determinations of the same quantity which are chiefly dependent upon the effects of high temperatures assumed to prevail at such a depth. At fusion temperatures liquefaction

[FIG. 3.—Average Velocities for Preliminary Tremors if propagated along Chords.]



is a state for many substances which is promoted by pressure, whilst at still higher temperatures Arrhenius points out that whatever the pressure might be it seems probable that fluids would become gaseous, and such gases would be dense, but slightly compressible and viscous. What the velocity table (as it now stands) indicates is that a crust passes rapidly into a nucleus which is exceedingly rigid and fairly homogeneous. A specific gravity can be defined for this nucleus which will meet the requirements of gravitational observations, and it seems likely that the same may accord with the tests of the astronomer.

Isomorphous Sulphonic Derivatives of Benzene.—Fourth Report of the Committee, consisting of Professor H. A. MIERS (*Chairman*), Dr. H. E. ARMSTRONG (*Secretary*), Professor W. P. WYNNE *and* Professor W. J. POPE. (*Drawn up by the Secretary.*)

THE object the Committee have primarily in view is the crystallographic study of the complete series of sulphochlorides and sulphobromides derived from the isomeric dichloro-, dibromo- and chlorobromo-benzenes.

The results obtained in the case of the para- and two of the three series of meta-derivatives have been referred to in previous reports. It may be pointed out that whereas no evidence was obtained that the 1 : 4 derivatives exist in polymorphic forms—the five compounds measured

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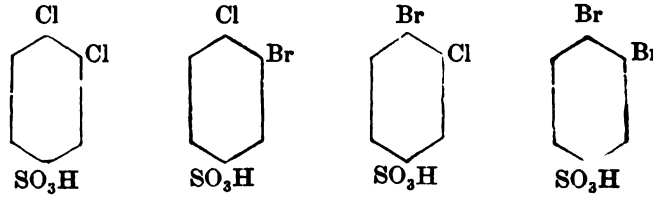
being strictly isomorphous,[1] in the case of the meta-derivatives, the 1 : 3 : 4 series formed an isotrimorphous group, the 1 : 3 : 5 series an isotetramorphous group.

During the past year Mr. Harding has determined the constants of five of the eight members of the 1 : 2 : 4 ortho-series, viz., the chlorides derived from the acids Nos. I, II, and IV and the bromide of acid No. II :—



Of the chlorides, I and II are practically identical crystallographically; the chloride of IV was obtained in quite a distinct form, belonging, however, to the same crystallographic system. The bromide of II was obtained in both these forms, so that it establishes a connecting link between the two isomorphous series which evidently exist.

Great difficulty was experienced in making the measurements owing to the low melting-points of the sulphon-halides and the extraordinary way in which they crystallise (from a mixture of benzene and petroleum) in very thin micaceous plates; it was discovered, however, that by using petroleum of higher boiling-point more massive crystals could be obtained; forms fit for measurement were eventually secured by this artifice.

It would seem that the character of the solvent has a definite influence on crystalline form, especially in the case of substances which manifest polymorphism. When opportunity offers it will undoubtedly be desirable to study this question experimentally.

The anilides, which have higher melting-points than the halides, crystallise with much greater facility; the opportunity has been taken to study several of these. Mr. Harding finds that the orthodichloranilide exists in two forms, one orthorhombic the other monosymmetric; and that whilst the dibromo- and bromochloranilides crystallise in a form isomorphous with the monosymmetric form of the dichloranilide, the fourth anilide crystallises in a second monosymmetric form.

Mr. Harding has also measured the 1 : 3 dibromo- 2 sulphochloride and has thus made a beginning with the 1 : 2 : 3 meta-series.

Although the material is available, it has been impossible hitherto to obtain two of the para-compounds and three 1 : 2 : 4 derivatives in forms suitable for measurement; it is hoped that the difficulty will be overcome and that the experience which has been gained will make it possible to extend the investigation to the remaining terms of the meta- and ortho-series at no distant date. It is very desirable, for this purpose, to have large quantities of material at disposal and that special apparatus should be devised which will make it possible to effect the crystallisation under constant conditions.

[1] Mr. Harding has recently been able to obtain a sixth member of this series—the 1 Cl : 4 Br : 3 sulphobromide—in measurable form, and finds that it is isomorphous with five which Mr. Gidden measured. Mr. Gidden did not succeed in preparing this compound.

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Wave-length Tables of the Spectra of the Elements and Compounds.—*Report of the Committee, consisting of* Sir H. E. ROSCOE (*Chairman*), Dr. MARSHALL WATTS (*Secretary*), Sir J. N. LOCKYER, Professor J. DEWAR, Professor G. D. LIVEING, Professor A. SCHUSTER Professor W. N. HARTLEY, Professor WOLCOTT GIBBS, *and* Captain Sir W. DE W. ABNEY.

MOLYBDENUM (ARC SPECTRUM).

Hasselberg, 'Kongl. Svenska Vetenskaps-Akadem. Handl.,' Bd. 36, No. 2, 1902.

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
5893·67	4		1 61	4·6	16962·8
91·89	2		1·60	,,	967·9
88·61	8		,,	,,	977·3
83·11	2		,,	,,	993·2
81·85	2		,,	,,	996·8
76·90	2		,,	,,	17011·2
69·57	4		,,	,,	032·4
69·05	2		,,	,,	033·9
61·66	2		,,	,,	055·4
58·52	8		,,	,,	064·6
51·80	4		1·59	,,	084·1
49·99	4		,,	,,	089·4
49·16	3		,,	,,	091·9
40·25	2		,,	,,	118 0
35·87	2		,,	4·7	130·7
25·50	3		,,	,,	161·2
25·28	2		,,	,,	161·8
21·00	2		,,	,,	174·5
16·00	2		,,	,,	189·2
15·76	2		,,	,,	190·0
14·14	2		,,	,,	194·7
09·30	2		,,	,,	209·1
08·54	2		,,	,,	211·3
06·46	2		,,	,,	217·5
02·95	4		,,	,,	227·9
00·72	4		,,	,,	234·5
5792·10	8		,,	,,	260·2
85·99	2		,,	,,	278·4
83·54	4		,,	,,	285·7
80·96	2		,,	,,	293·5
80 38	2		,,	,,	295·2
79·65	4		,,	,,	297·4
78·46	2		,,	,,	301·9
74·85	3		,,	,,	311·8
71·33	2		,,	,,	322·3
70·02	2		,,	,,	326·3
67·63	2		,,	,,	333·4
66·79	2		,,	,,	336·0
65·57	2		,,	,,	339·6
57·80	2		,,	,,	363·0
51 67	9		,,	,,	381·8

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
5747·93	2		1·59	4·7	17392·9
47·08	2		,,	,,	395·4
41·96	2		,,	,,	411·0
39·93	2		,,	,,	417·1
38·40	2		,,	,,	421·7
35·55	2		,,	,,	430·4
34·32	4		,,	,,	434·1
31·58	2		,,	4·8	442·4
30·17	4		,,	,,	446·7
29·77	4		,,	,,	447·9
29·03	4		,,	,,	450·2
22·98	7		,,	,,	468·6
20·45	2		,,	,,	476·3
19·55	2		,,	,,	480·1
12·05	4	5712·0 Ti	,,	,,	502·0
08·28	2		,,	,,	513·6
05·97	6		,,	,,	520·7
02·39	3		,,	,,	531·7
5699·87	4		,,	,,	539·5
98·53	4		,,	,,	543·6
96·30	3		,,	,,	550·5
95·66	2		,,	,,	552·4
95·10	2		,,	,,	554·1
94·64	2		,,	,,	555·6
89·39	9		,,	,,	571·8
87·93	2		,,	,,	576·2
83·20	4		,,	,,	590·9
78·18	5		,,	,,	606·4
74·77	5		,,	,,	617·1
73·92	4		,,	,,	619·7
72·35	2		,,	,,	624·6
67·57	3		,,	,,	639·4
64·65	3		,,	,,	648·5
52·47	2		,,	,,	686·6
52·12	3		,,	,,	687·7
51·54	2		,,	,,	689·5
50·40	8		,,	,,	693·0
43·47	2		,,	,,	714·8
42·05	2	5642·11 Ni	,,	,,	719·2
35·14	5		,,	,,	741·0
32·74	8		,,	,,	748·5
19·63	4		,,	,,	789·9
19·03	3		,,	,,	791·9
18·69	4		,,	,,	792·9
13·37	4		,,	,,	809·8
11·20	6		,,	,,	816·7
09·80	2		,,	4·9	821·0
09·53	4		,,	,,	821·9
08·90	4		,,	,,	823·9
01·31	3		,,	,,	848·1
5596·62	3		,,	,,	863·0
91·84	4		,,	,,	878·3
89·02	4	5588·98 Ca	,,	,,	887·4
75·47	4		,,	,,	931·8
70·69	12		,,	,,	946·2

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MOLYBDENUM (ARC SPECTRUM)—*continued*.

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
5569·75	4		1·59	4·9	17949·2
68·88	5		,,	,,	955·5
64·34	4		,,	,,	966·7
63·65	2		,,	,,	968·9
62·74	2		,,	,,	971·8
57·02	4		,,	,,	990·4
52·47	2		,,	,,	18006·1
44·78	4s		,,	,,	030·1
43·38	4s	5543·41 Fe	,,	,,	034·6
41·93	2s		,,	,,	039·4
39·67	4s		,,	,,	046·7
34·85	2		,,	,,	062·4
33·26	12		,,	,,	067·6
32·00	2		,,	,,	071·7
27·27	4		,,	,,	087·2
26·81	4		,,	,,	088·7
20·93	3		,,	,,	108·0
20·32	3		,,	,,	110·0
17·73	2		,,	,,	118·5
11·77	2		,,	,,	138·1
06·75	12		,,	,,	154·6
03·82	3		,,	5·0	164·2
02·18	4		,,	,,	169·6
01·78	4s		,,	,,	170·9
5499·77	2n		,,	,,	177·6
98·76	4s		,,	,,	180·9
97·18	3n		,,	,,	186·1
94·06	4		,,	,,	196·5
92·43	4		,,	,,	200·9
90·54	4		,,	,,	208·2
88·91	2		,,	,,	213·6
76·18	4		,,	,,	255·9
73·64	6		,,	,,	264·4
65·83	4		,,	,,	290·5
56·71	4		,,	,,	320·7
53·27	4		,,	,,	332·6
50·73	5		,,	,,	341·2
48·78	2		,,	,,	347·7
47·86	2		,,	,,	350·8
39·95	2		,,	,,	377·5
37·97	5		,,	,,	384·2
35·91	4		,,	,,	391·2
31·27	2		,,	,,	406·9
27·80	2		,,	,,	418·7
27·14	3		,,	,,	420·9
26·24	2		,,	,,	424·0
17·64	3		,,	,,	453·2
14·95	2		,,	,,	462·4
11·31	2		,,	,,	474·8
06·64	3		,,	,,	490·8
5397·63	3		,,	5·1	521·5
94·75	4s	5394·91 } Mn 5394·84 }	,,	,,	531·4
88·94	2		,,	,,	551·1
72·63	2		,,	,,	607·8

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
5367·30	4n		1·59	5·1	18626·2
64·50	7		,,	,,	636·0
60·76	9		,,	,,	649·0
56·70	4		,,	,,	663·1
55·76	2		,,	,,	666·4
55·12	4		,,	,,	668·6
27·35	2		,,	,,	666·0
24·70	2		,,	,,	675·3
20·14	2		,,	,,	796·4
18·20	2		,,	,,	798·3
14·13	4		,,	,,	812·7
06·49	2		,,	,,	839·8
5295·67	3		,,	5·2	878·2
93·65	2		,,	,,	885·4
92·30	3		,,	,,	890·2
81·07	4		,,	,,	930·3
79 85	4		,,	,,	934·7
76·50	2		,,	,,	946·8
72·00	2		,,	,,	962·9
61·35	4		,,	,,	19001·3
59·23	4		,,	,,	009·0
45·71	4		,,	,,	058·0
43·01	4		,,	,,	067·8
41·09	6		,,	,,	074·8
38·41	6		,,	,,	084·6
34·47	4		,,	,,	098·9
32·58	2		,,	,,	105·8
31·27	2		,,	,,	110·6
19·62	3		,,	,,	153·3
12·08	2		,,	,,	181·1
00·97	2		,,	5·3	223·8
00·37	4		,,	,,	224·0
5180·44	3		,,	,,	298·1
74·35	6		,,	,,	320·8
73·14	6		,,	,,	325·3
71·33	6		,,	,,	332·1
67·98	4		,,	,,	344·6
63·40	4		,,	,,	361·8
55·48	2		,,	,,	391·5
48·65	2		,,	,,	418·3
41·47	2		,,	,,	444·4
35·17	2		,,	,,	468·2
26·94	2		,,	,,	501·5
24·03	2		,,	,,	510·6
22·00	2		,,	,,	518·3
17·18	3		,,	,,	536·7
15·86	2		,,	5·4	541·7
15·21	4		,,	,,	544·1
09·90	4	5109·83 Fe	,,	,,	564·5
00·58	2		,,	,,	600·2
5098·27	3		,,	,,	609·1
97·71	5	5097·67	,,	,,	611·3
96·85	4		,,	,,	614·6
96·11	3		,,	,,	616·4
92·96	2		,,	,,	630·9

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
5092·40	2		1·59	5·4	19631·7
91·56	2		,,	,,	634·9
91·17	3		,,	,,	636·4
90·80	2		,,	,,	637·9
84·47	2		,,	,,	662·3
81·49	2		,,	,,	673·9
80·23	5		,,	,,	678·7
62·76	2		,,	,,	746·7
60·07	5		,,	,,	757·2
58·30	2		,,	,,	764·1
55·22	3		,,	,,	776·1
47·90	4		,,	,,	804·8
46·73	2		,,	,,	809·4
39·12	2		,,	,,	839·3
30·96	4		,,	,,	871·5
29·21	4		,,	,,	878·4
20·07	2		,,	5·5	914·7
16·99	5		,,	,,	926·8
14·80	2		,,	,,	935·5
00·13	4		,,	,,	994·0
4995·55	2		,,	,,	20012·3
79·32	5		,,	,,	077·5
76·23	2		,,	,,	090·0
75·58	2		,,	,,	092·6
64·63	4		,,	,,	137·0
64·42	3		,,	,,	137·8
57·78	6	4957·88 Fe	,,	,,	164·8
56·83	2		,,	,,	168·7
52·20	2		,,	,,	187·5
50·83	5		,,	,,	193·1
41·90	4		,,	5·6	229·5
33·99	2		,,	,,	262·0
33·30	4		,,	,,	264·8
31·42	2		,,	,,	272·6
26·65	4		,,	,,	292·2
26·42	4		,,	,,	293·1
25·08	2		,,	,,	298·6
09·41	2		,,	,,	363·5
07·65	2		,,	,,	371·8
04·03	5		,,	,,	385·8
4899·81	2		,,	,,	410·5
97·50	2		,,	,,	413 0
94·65	2		,,	,,	424·9
89·44	2		,,	,,	446·6
86·70	2		,,	,,	462·3
78·59	3		,,	,,	492·1
75·73	2	4875·67 V	,,	,,	504·3
69·43	4		,,	,,	530·7
68·23	6		,,	,,	535·7
66·07	2		,,	,,	544·9
60·99	2		,,	5·7	566·3
60·28	3		,,	,,	569·2
58·44	3		,,	,,	577·0
51·92	2		,,	,,	604·7
50·05	2		,,	,,	612·7

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
4845·38	2		1·59	5·7	20632·5
39·82	2		,,	,,	656·2
38·35	2		,,	,,	662·0
35·98	2		,,	,,	672·6
34·16	4		,,	,,	680·4
33·13	2		,,	,,	684·8
30·73	6s		,,	,,	695·1
30·15	2		,,	,,	697·6
28·67	4s		,,	,,	704·0
23·16	2		,,	,,	727·6
22·62	2		,,	,,	729·9
19·47	6		,,	,,	743·4
17·92	4		,,	,,	750·1
14·68	2		,,	,,	764·2
11·28	5		,,	,,	778·7
08·68	2		,,	,,	790·0
08·29	4	08·32 Fe	,,	,,	791·7
05·78	4		,,	,,	802·5
05·13	2		,,	,,	804·9
4796·75	5s		,,	,,	841·7
94·81	2		,,	,,	850·2
94·03	3		,,	,,	853·9
93·60	4		,,	,,	855·4
92·96	4		,,	,,	858·2
88·39	2		,,	,,	878·1
87·83	2		,,	,,	880·6
86·68	4	4786·73 Ni 86·70 V	,,	,,	885·6
85·34	5s		,,	,,	891·3
84·64	2		,,	,,	894·5
83·16 ‡	5	83·17	,,	,,	901·0
78·09	2		,,	5·8	923·0
76·54 ‡	6 also V	76·55 Cc	,,	,,	929·9
75·87	5		,,	,,	932·8
74·42	4		,,	,,	939·1
73 64	4		,,	,,	942·6
73·47	3		,,	,,	943·2
64·64	4s		,,	,,	982·1
60·39	8		,,	,,	21000·9
58·71	5		,,	,,	008·3
56·06	2		,,	,,	020·0
53·56	2		,,	,,	031·1
51·31	2		,,	,,	041·0
50·60	5s		,,	,,	044·2
49·61	2		,,	,,	048·5
49·35	2		,,	,,	049·7
49·06	2		,,	,,	051·0
40·58	2		,,	,,	088·7
40·36	2		,,	,,	089·6
36·84	2		,,	,,	105·3
35·51	2		,,	,,	111·2
34·34	2		,,	,,	116·5
31·64	7		,,	,,	129·4
29·36	6		,,	,,	138·7
25·55	2		,,	,,	155·7

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
4723·50	2		1·59	5·8	21164·9
23·27	3		,,	,,	175·9
19·08	4		,,	,,	185·0
18·13	5		,,	,,	189·0
16·88	2		,,	,,	194·7
14·69	4		,,	,,	204·3
10·16	2		,,	,,	224·9
08·43	6		,,	,,	232·7
07·44	7	4707·46 Fe	,,	5·9	237·2
06·40	2		,,	,,	241·7
06·25	4	also Cr	,,	,,	242·4
00·71	4		,,	,,	267·5
4696·71	3		,,	,,	285·6
96·06	2		,,	,,	288·6
93·55	2		,,	,,	299·9
92·89	2		,,	,,	302·9
92 19	2		,,	,,	306·1
91·05	4		,,	,,	311·3
88·41	5	4688·46 Fe	,,	,,	323·3
86·28	4		,,	,,	333·0
86·01	4		,,	,,	334·2
84·54	2		,,	,,	340·9
84·04	3		,,	,,	343·2
82·44	2		,,	,,	350·5
81·82	2		,,	,,	353·3
81·24	2		,,	,,	356·0
75·91	2		,,	,,	384·9
73·24	2		,,	,,	392·5
72·11	6		,,	,,	397·7
69·00	2		,,	,,	412·0
65·59	2		,,	,,	427·6
63·31	2		,,	,,	438·0
62·95 ‡	6	4662·93	,,	,,	439·7
62·11	5		,,	,,	443·6
57·67	2		,,	,,	464·0
56·57	2		,,	,,	469·1
52·47 *	4		,,	,,	488·0
51·25	4		,,	,,	493·6
49·28	3		,,	,,	502·8
48·02	4s		,,	,,	508·6
42·90	3		,,	,,	532·4
41·78	2		,,	,,	537·6
41·12	2		,,	,,	540·6
35·22	2		,,	6·0	572·6
32·75	2		,,	,,	579·5
30·20	4s		,,	,,	591·3
27·70 ‡	5	4627·73	,,	,,	603·0
26·67	7	also V 4626·74 Mn	,,	,,	607·8
24·44	4		,,	,,	618·2
23·66	3s		,,	,,	621·9
21·57	5s		,,	,,	631·7
18·15	2s		,,	,,	647·7
17·82	2		,,	,,	649·2
16·81 *	2		,,	,,	654·0

* Probably not due to Molybdenum.

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
4614·94	2		1·59	6·0	21662·7
11·36	4s		,,	,,	679·6
11·03	2		,,	,,	681·0
10·07 ‡	6	4610·09	,,	,,	685·6
08·90	2s		,,	,,	696·1
08·32	2		,,	,,	693·9
03·78	2		,,	,,	715·3
4599·35	4		,,	,,	736·2
98·44	2		,,	,,	740·3
98·07	2		,,	,,	742·3
95·35	6		,,	,,	755·1
93·84	2		,,	,,	762·3
92·40	3s		,,	,,	769·1
90·55	4n		,,	,,	777·9
88·33	3n		,,	,,	788·4
87·61	2		,,	,,	791·8
86·98	2		,,	,,	794·8
86·75	2		,,	,,	795·9
86·25	2		,,	,,	798·3
82·69	2		,,	,,	815·2
82·52	2		,,	,,	816·0
79·92	2		,,	,,	828·4
78·06	2		,,	,,	837·3
77·97	2s		,,	,,	837·7
76·70	6s		,,	,,	843·8
76·05	2		,,	,,	846·9
75·36	2		,,	,,	849·2
74·80	2		,,	,,	852·9
74·66	2		,,	,,	853·5
70·78	2s		,,	,,	872·1
70·30	4s		,,	,,	874·4
69·21	2		,,	,,	879·6
67·87	4		,,	,,	886·0
67·57	2		,,	,,	887·5
60·32	4s	4560·27 Fe	,,	6·1	922·2
59·94	2		,,	,,	924·0
58·92	3		,,	,,	928·9
58·30 ‡	5	4558·29	,,	,,	931·9
54·00	4		,,	,,	952·6
53·52	3		,,	,,	954·9
53·40	3		,,	,,	955·5
53·00	2		,,	,,	957·4
41·75	4		,,	,,	22011·8
39·84	2		,,	,,	021·1
38·60	2		,,	,,	026·1
37·00	6		,,	,,	034·9
35·56	4		,,	,,	041·9
35·00	4		,,	,,	044·6
34·63	4		,,	,,	046·4
29·59	5		,,	,,	070·9
28·77	5	4258·80 Fe	,,	,,	075·0
25·56	4		,,	,,	090·6
25·50	2		,,	,,	090·9
24·53	6		,,	,,	095·6
22·37	4		,,	,,	106·2

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4518·61	2		1·59	6·1	22124·6
17·58	4		,,	,,	129·6
17·30 ‡	6	4517·28 4517·32 Co	,,	,,	136.1
15·36	4		,,	,,	140·5
15·20	3		,,	,,	141·3
12·32	5		,,	,,	155·4
06·86	4		,,	,,	182·3
06·22 }	6		,,	,,	185·4
06·13 }			,,	,,	185·9
01·44	4	4501·42 Ti	,,	,,	209·0
4499·62	4		,,	,,	218·2
94·27	2		,,	6·2	244·3
92·24	2		,,	,,	244·4
92·00	2		,,	,,	255·6
91·46	6		,,	,,	258·3
90·37	4		,,	,,	263·7
89·17	3		,,	,,	269·6
87·23	4		,,	,,	278·7
85·16	5		,,	,,	289·5
75·82	4		,,	,,	336·1
74·78	8		,,	,,	341·3
73·37	5		,,	,,	348·3
72·23	3		,,	,,	354·0
71·85	3		,,	,,	355·9
68·46	6		,,	,,	372·9
68·28	2		,,	,,	373·8
64·96	6	4464·94 Fe	,,	,,	390·4
60·80	4		,,	,,	411·3
58·84	3		,,	,,	421·2
57·55	7		,,	,,	427·6
52·77	3		,,	,,	451·7
49·92	6		,,	,,	466·1
47·41	3		,,	,,	478·8
46·62	4s		,,	,,	482·8
44·21	2n		,,	,,	495·0
43·25	4s		,,	,,	499·8
42·37	5s		,,	,,	504·3
39·15	2s		,,	,,	520·6
37·35	2		,,	,,	529·7
37·06	4		,,	,,	531·2
33·68	3s		,,	,,	548·4
29·32	2		,,	6·3	570·5
28·39	2		,,	,,	576·3
26·86	5		,,	,,	583·3
24·40	2		,,	,,	585·6
23·79	5		,,	,,	598·8
23·24	2 also Ni		,,	,,	601·4
22·23	3		,,	,,	606·7
20·91	2		,,	,,	613·5
17·40	2		,,	,,	631·4
12·96	4		,,	,,	654·2
11·90	6		,,	,,	659·7
11·76	5		,,	,,	660·4
10·15	4		,,	,,	668·6
09·61	2		,,	,,	671·4

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
4407·04	2		1·59	6·3	22684·7
04·71	3s		,,	,,	696·7
03·07	4		,,	,,	705·1
02·67	4		,,	,,	707·2
4398·68	2		,,	,,	727·8
97·48	4		,,	,,	734·0
97·02	2		,,	,,	736·4
96·83	4s		,,	,,	737·3
96·55	2		,,	,,	738·8
94·67	3		,,	,,	748·5
94·49	3		,,	,,	749·7
92·32	3		,,	,,	760·7
91·71	3		,,	,,	763·9
89·76	2		,,	,,	774·0
88·49	2		,,	,,	780·5
86·10	2		,,	,,	792·9
82·61	4		,,	,,	811·2
81·82	8		,,	,,	815·3
81·36	2		,,	,,	817·6
80·80	3s		,,	,,	820·6
80·47	4		,,	,,	822·3
76·87	2		,,	,,	841·1
75·21	3		,,	,,	849·7
75·07	2		,,	,,	850·4
73·52	2		,,	,,	858·6
72·31	2		,,	,,	864·9
70·33	2		,,	,,	875·3
69·23	5		,,	,,	881·0
66·73	4		,,	6·4	894·0
64·90	2		,,	,,	903·6
64·76	2		,,	,,	904·3
64·65	3		,,	,,	904·9
63·82	3		,,	,,	909·3
63·21	2		,,	,,	912·5
62·87	2		,,	,,	914·3
62·20	3		,,	,,	917·8
57·50	3		,,	,,	942·5
54·88	2		,,	,,	956·3
53·48	4		,,	,,	963·7
50·53	6		,,	,,	979·3
49·41	2		,,	,,	985·2
46·40	2		,,	,,	23001·1
44·86	3		,,	,,	009·3
42·16	2		,,	,,	023·6
41·61	4		,,	,,	026·5
40·93	4		,,	,,	030·1
40·02	3		,,	,,	035·0
39·42	2		,,	,,	038·2
38·90	4		,,	,,	040·9
38·73	2		,,	,,	041·8
36·38	2		,,	,,	054·4
35·00	4		,,	,,	061·6
34·65	2		,,	,,	063·5
33·40	2		,,	,,	070·2
32·68	2		,,	,,	074·0

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4330·27	2		1·59	6·4	23086·9
29·82	3		,,	,,	089·3
29·50	2		,,	,,	091·0
26·33	6		,,	,,	107·9
25·44	2		,,	,,	112·6
24·72	2		,,	,,	116·5
22·60	2		,,	,,	127·8
22·17	4		,,	,,	130·3
18·46	2		,,	,,	150·0
18·13	5		,,	,,	151·8
15·60	2		,,	,,	165·4
13·74	2		,,	,,	175·3
13·16	3		,,	,,	182·4
12·98	3		,,	,,	179·6
10·58	4	4310·63 10·54	,,	,,	192·3
08·85	2		,,	6·5	201·8
05·10	4		,,	,,	221·8
04·20	3		,,	,,	226·5
01·45	3		,,	,,	241·5
4296·35	3		,,	,,	269·0
94·07	6		,,	,,	281·4
93·42	6		,,	,,	285·0
92·34	6		,,	,,	290·8
91·39	4		,,	,,	296 0
89·56	4	4289·50 Ca	,,	,,	305·9
88·82	6		,,	,,	309·5
87·26	4		,,	,,	319·4
84·77	6n		,,	,,	332·3
82·00	4		,,	,,	347·1
80·17	2		,,	,,	359·0
79·19	2		,,	,,	362.4
77·58	4	77·54 Zr	,,	,,	371·2
77·38‡	6	77·38	,,	,,	372·3
77·08	6		,,	,,	373·9
75·86	2		,,	,,	380·6
74·22	2		,,	,,	389·5
73·23	3s		,,	,,	395·0
72·24	3		,,	,,	400·4
69·44‡	5	69·45	,,	,,	415·8
68·25	4		,,	,,	422·3
66·27	4		,,	,,	433·2
64·81	2		,,	,,	441·2
61·63	3		,,	,,	458·7
61·17	2		,,	,,	461·3
60·85	3	60·89	,,	,,	463·0
60·52	3		,,	,,	464·8
58·85	2		,,	,,	472·0
53·77	2		,,	,,	502·0
52·69	2		,,	6·6	507·9
52·03	5		,,	,,	511·6
51·58	2		,,	,,	514·1
50·87	3		,,	,,	518·0
46·19	5	46·25 Fe	,,	,,	543·9
44·95	3n		,,	,,	550·8

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
4242·97	3		1·59	6·6	23561·8
41·03	5		,,	,,	572·6
40·48	4		,,	,,	575·6
40·26	4 also V		,,	,,	576·8
39·37	4		,,	,,	581·4
39·25	4		,,	,,	582·5
35·23	3		,,	,,	604·8
33·68	3		,,	,,	613·5
32·75	6		,,	,,	618·7
26·44	3		,,	,,	654·0
25·10	2		,,	,,	661·5
24·93	2		,,	,,	662·4
24·10	2		,,	,,	666·1
23·15	3		,,	,,	672·4
22·59	3		,,	,,	675·5
20·17	2		,,	,,	688·1
19·55	4	{ 19·58 Fe 19·52 Fe	,,	,,	692·6
19·20	2		,,	,,	694·6
17·02	2		,,	,,	706·8
14·24	3		,,	,,	722·5
11·23	4		,,	,,	739·5
10·39	2		,,	,,	744·2
09·84	2		,,	,,	747·3
08·97	2		,,	,,	753·2
07·75	2		,,	,,	759·1
07·42	2		,,	,,	761·0
06·00	4		,,	,,	769·0
04·80	3		,,	,,	775·7
02·42	2		,,	,,	788·2
01·50	3		,,	,,	794·4
01·35	2		,,	,,	795·3
00·76	3		,,	,,	798·6
00·02	2		,,	6·7	802·7
4199·82	2		,,	,,	803·8
94·74	5		,,	,,	832·7
94·20	2		,,	,,	835·8
88·49	8		,,	,,	868·2
86·97	4		,,	,,	876·9
85·98‡	6	4185·94	,,	,,	882·6
84·59	2		,,	,,	890·5
84·33	2		,,	,,	892·0
81·24	4		,,	,,	909·6
80·69	3		,,	,,	912·8
80·12	3		,,	,,	916·0
78·72	2		,,	,,	924·1
78·45	4		,,	,,	925·6
77·45	4		,,	,,	931·3
77·09	3		,,	,,	933·4
75·32	2		,,	,,	943·6
71·65	2		,,	,,	964·6
71·27	3	71·21 Ti	,,	,,	966·8
70·55	2		,,	,,	971·2
70·01	4	69·93 Fe	,,	,,	974·1
68·68	3		,,	,,	981·7

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4166·47	3		1·59	6·7	23994·4
65·94	2		,,	,,	997·5
64·26	3		,,	,,	24007·1
62·85†	5	62·83	,,	,,	015·3
60·44	2		,,	,,	029·2
58·27	2		,,	,,	041·7
57·59	5		,,	,,	045·7
55·77	5		,,	,,	056·8
55·47	5		,,	,,	058·0
52·07†	4	52·11	,,	,,	077·7
49·90	2		,,	,,	090·3
49·14	5		,,	6·8	094·6
48·88	2		,,	,,	102·3
43·73	8		,,	,,	126·0
42·28	3		,,	,,	134·5
39·72	2		,,	,,	149·4
38·72	3		,,	,,	155·3
38·35	3		,,	,,	156·9
37·10	2		,,	,,	164·7
35·55	2		,,	,,	173·8
35·37	2		,,	,,	174·8
33·18	2		,,	,,	187·6
32·90	2		,,	,,	189·3
32·41	4		,,	,,	192·1
32·07	4		,,	,,	194·1
29·02	4		,,	,,	212·0
28·46	4		,,	,,	215·3
24·72	4		,,	,,	217·3
23·83	4		,,	,,	242·5
22·55	2		,,	,,	250·0
20·26	6		,,	,,	263·5
19·18	2		,,	,,	269·9
19·12†	4	19·05 Fe	,,	,,	270·2
15·08	4		,,	,,	294·2
13·77	2		,,	,,	301·8
12·29	2		,,	,,	310·5
10·88	2		,,	,,	318·9
10·46	2		,,	,,	321·4
08·30	3	08·29	,,	,,	334·2
07·63	6		,,	,,	338·1
05·72	4		,,	,,	349·4
05·27	4		,,	,,	352·1
03·94	3		,,	,,	360·0
02·33‡	5	02·32 V	,,	,,	369·6
4098·91	4		,,	6·9	389·8
96·98	4		,,	,,	401·3
94·63	2		,,	,,	415·3
93·32	2		,,	,,	423·1
89·90	3		,,	,,	443·6
86·16†	4	4086·13	,,	,,	466·0
84·54‡	6	84·58	,,	,,	475·7
81·94	4		,,	,,	491·3
81·62	6		,,	,,	493·2
78·25	2		,,	,,	513·4

† Not coincident with Fraunhofer line.

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4076·69	3	{ 76·80 76·64	1·59	6·9	24522·8
76·35	4		,,	,,	524·8
75·72	4		,,	,,	528·6
75·43	4		,,	,,	530·4
70·17	4		,,	,,	562·0
70·05	6		,,	,,	562·8
67·88	2		,,	,,	582·4
66·52	4	66·52 Co	,,	,,	584·2
62·24	5		,,	,,	610·0
59·79	4		,,	,,	624·9
57·77	3 also Ti		,,	,,	637·2
57·61	2		,,	,,	638·1
56·18	4	{ 56·22 Cr 56·13 Fe	,,	,,	646·8
51·35	2		,,	7·0	676·1
50·27	2		,,	,,	682·6
49·75	2		,,	,,	685·9
47·75	2		,,	,,	698·2
47·56	2		,,	,,	699·2
47·07	2		,,	,,	702·2
43·91	3		,,	,,	721·5
43·44	2		,,	,,	724·4
43·05	4		,,	,,	726·8
41·30	3		,,	,,	737·5
38·26	4		,,	,,	755·6
37·95	4		,,	,,	758·0
36·83	2		,,	,,	764·9
43·11	2		,,	,,	787·7
32·65	3	32·61 Fe V	,,	,,	790·6
31·60	2		,,	,,	797·0
31·06	2		,,	,,	800·4
28·80	3		,,	,,	814·3
27·07	2		,,	,,	824·9
25·64	3		,,	,,	833·8
21·19	4		,,	,,	861·2
20·59	3	{ 20·64 Fe 20·55 Sc	,,	,,	865·0
19·32	2		,,	,,	872·8
17·55	3		,,	,,	883·8
16·86	2		,,	,,	888·1
12·97	2		,,	,,	912·2
12·68	2		,,	,,	914·0
12·42	2		,,	,,	915·6
12·12	4n		,,	,,	917·4
09·53	4		,,	,,	933·6
08·21	2		,,	,,	941·8
07·62	2		,,	,,	945·4
06·85	2		,,	,,	950·2
06·23	4		,,	,,	954·1
05·86	2 also V		,,	,,	956·4
03·62	2		,,	7·1	970·2
00·67	4	00·61 Fe	,,	,,	986·7
00·55	4		,,	,,	989·4
3998·45	4		,,	,,	25002·6

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
3995·66	1		1·59	7·1	25020·6
94·79	2		,,	,,	025·5
94·06	4		,,	,,	030·1
93·22	3		,,	,,	035·3
92·02	4		,,	,,	042·9
91·55	4		,,	,,	045·8
86·45	4		,,	,,	077·9
85·88	3		,,	,,	081·5
84·92	2		,,	,,	087·5
82·22	4		,,	,,	100·7
81·80	3		,,	,,	107·2
80·87	3		,,	,,	113·0
80·37	4		,,	,,	116·2
79·40	4		,,	,,	122·3
78·08	4		,,	,,	130·6
74·09	4		,,	,,	155·9
73·92	4		,,	,,	157·0
73·10	2		,,	,,	162·1
71·54	3		,,	,,	172·1
69·17‡	2	3969·29 Cr, Co	,,	,,	187·1
68·91	4		,,	,,	188·9
66·40	3		,,	,,	204·7
65·89	3		,,	,,	208·4
64·14	4		,,	,,	219·0
63·68	3		,,	,,	222·0
60·12	2	61·57 Al	,,	,,	245·6
59·83	2		,,	,,	246·5
59·03	2		,,	,,	251·6
58·76	4		,,	,,	253·3
55·66	4		,,	7·2	273·1
54·08	4		,,	,,	283·1
51·70	2		,,	,,	298·4
51·49	2		,,	,,	299·7
51·14	4		,,	,,	301·9
50·40	2		,,	,,	306·7
47·33	4		,,	,,	326·4
47·00	2		,,	,,	328·5
45·41	4	45·47 Co	,,	,,	338·7
43·66	4	44·10 Al	,,	,,	350·0
43·19	6		,,	,,	353·0
40·50	2		,,	,,	368·2
39·65	2		,,	,,	375·8
39·30	2		,,	,,	378·0
38·88	3		,,	,,	380·7
36·89	2		,,	,,	393·6
36·30	2		,,	,,	397·4
35·33	3		,,	,,	403·6
35·13	4		,,	,,	404·9
34·41	3		,,	,,	409·6
31·57	3		,,	,,	427·9
30·35	3		,,	,,	435·8
28·95	3		,,	,,	444·9
28·86	3		,,	,,	445·5
28·45	3		,,	,,	448·1
26·00	2		,,	,,	464·0

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
3924·78	2		1·59	7·2	25471·9
23·91	4		,,	,,	477·6
22·49	4		,,	,,	486·8
21·09	2		,,	,,	495·9
20·25	2		,,	,,	501·4
17·95	4		,,	,,	516·4
17·70	4		,,	,,	518·0
17·09	4		,,	,,	521·9
16·62	2		,,	,,	525·0
15·60	2		,,	,,	531·7
13·52	3		,,	,,	545·2
12·10	3		,,	,,	554·2
11·24	3n		,,	,,	560·1
09·92	3		,,	,,	568·8
08·42	3		,,	7·3	578·5
07·10	4		,,	,,	587·1
03·07	20n, r		,,	,,	613·6
01·95	5		,,	,,	621·0
00·87	2		,,	,,	628·0
00·40	2		,,	,,	631·1
3897·68	2		,,	,,	649 0
97·05	3		,,	,,	653·1
96·55	3		,,	,,	656·4
93·50	2	3893·54 Fe	,,	,,	676·5
90·88	3	93·45 Co	,,	,,	693·8
89·06	4		,,	,,	705·9
88·36	4		,,	,,	710·5
88·15	2		,,	,,	711·9
87·87	2		,,	,,	713·7
86·98	5	86·94	,,	,,	719·6
79·20	2		,,	,,	771·2
74·34	3	74·32 Ti	,,	,,	803·5
73·30	3	73·25 Co	,,	,,	810·4
70·77	3		,,	,,	827·3
70·62	3		,,	,,	828·3
69 25	5		,,	,,	837·5
66·87	2		,,	,,	853·4
64·25	20n, r	64·23 Mo, C	,,	,,	870·9
56·15	3		,,	,,	925·2
55·09	2		,,	,,	932·4
52·17	4		,,	,,	952·0
51·57	2		,,	,,	956·2
49·95	2		,,	,,	967·1
48·45	4	48·48 Ti	,,	,,	977·2
47·41	4		,,	,,	984·2
46·36	3		,,	,,	991·3
46·12	4		,,	,,	992·9
44·09	3		,,	,,	26006·6
40·72	2		,,	,,	029·5
39·65	2		,,	,,	036 8
35·49	4n		,,	,,	065·0
35·15	3		,,	,,	067·3
34·82	3		,,	,,	069·5
33·92	6		,,	,,	075·7
32·26	4		,,	,,	087·0

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
3831·95	2		1·59	7·3	26089·1
31·25	3		,,	,,	093·8
30·98	4	31·00 } Fe	,,	,,	095·7
30·22	4	30·90 }	,,	,,	100·9
30·08	2		,,	,,	101·8
29·95	3		,,	,,	102·7
29·04	6		,,	,,	108·9
27·33	4		,,	,,	120·6
26·85	5		,,	,,	123·9
25·63	2		,,	,,	132·2
25·50	3		,,	,,	133·1
24·94	3		,,	,,	136·9
24·34	3		,,	,,	142·0
23·17	4		,,	,,	149·0
22·14	2		,,	,,	154·9
21·82	2		,,	,,	158·2
21·09	3		,,	,,	163·2
19·98	5		,,	,,	171·8
18·83	4		,,	7·4	178·7
17·37	2		,,	,,	188·6
15·24	3		,,	,,	203·3
14·64	2		,,	,,	207·4
12·63	4s		,,	,,	221·2
11·56	3s		,,	,,	228·6
10·99	2		,,	,,	232·5
10·31	2		,,	,,	237·2
08·79	3		,,	,,	248·3
08·04	2		,,	,,	252·8
07·82	2		,,	,,	254·3
06·15	4		,,	,,	265·9
04·70	4		,,	,,	275·9
02·35	2		,,	,,	292·1
02·00	5	01·98	,,	,,	294·6
00·28	2		,,	,,	306·4
3798·39	20nr	3798·40 Mo	,,	,,	319·5
97·46	4		,,	,,	326·0
97·20	3		,,	,,	327·9
96·45	2		,,	,,	332·9
96·19	3		,,	,,	334·8
95·48	2		,,	,,	339·7
94·60	4		,,	,,	345·8
88·42	4		,,	,,	388·8
86·54	2		,,	,,	401·9
85·67	3		,,	,,	408·0
85·19	4		,,	,,	411·4
82·86	2		,,	,,	427·6
82·35	3		,,	,,	431·2
81·75	5				435·4
80·78	2		,,	,,	442·3
79·92	4		,,	,,	448·2
77·90	3		,,	,,	462·3
76·73	2		,,	,,	469·8
76·27	2		,,	,,	473·8
72·99	4		,,	7·5	496·7
72·11	4		,,	,,	502·8

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
3770·66	5		1·59	7·5	26513·0
68.92	3		,,	,,	525·3
68·78	2		,,	,,	526·3
67·90	2		,,	,,	532·5
66·58	2		,,	,,	541·8
65·92	3		,,	,,	546·5
65·40	4		,,	,,	550·2
65·21	2		,,	,,	551·5
64·60	3		,,	,,	555·7
64·20	2		,,	,,	558·5
63·52	4 also Mn		,,	,,	563·3
62·27	3		,,	,,	572·1
61·93	4		,,	,,	574·6
61·07	4		,,	,,	580·7
59·80	3		,,	,,	589·6
58·70	4		,,	,,	597·4
56·02	3		,,	,,	616·4
55·68	2		,,	,,	619·0
55·31	4		,,	,,	621·5
52·12	2		,,	,,	644·1
51·38	4		,,	,,	649·5
48·66	4		,,	,,	668·7
47·37	4		,,	,,	677·9
45·12	3		,,	,,	693·9
44·55	4		,,	,,	698·0
43·98	2		,,	,,	702·0
42·48	5		,,	,,	712·6
40·97	2		,,	,,	723·5
38·10	4		,,	,,	744·0
36·36	2		,,	,,	756·5
35·80	3		,,	,,	760·5
34·56	3		,,	,,	769·4
33·59	2		,,	,,	776·4
33·22	4		,,	,,	779·0
32·91	6		,,	,,	781·3
30·75	2		,,	,,	796·8
28·70	4		,,	,,	811·5
28·50	3		,,	,,	813·0
27·86	6	3727·78 Fe	,,	7·6	817·4
26·45	4		,,	,,	827·6
25·75	4		,,	,,	832·6
24·00	2		,,	,,	845·2
23·70	3		,,	,,	847·6
22·50	2		,,	,,	856·0
20·42	4		,,	,,	871·1
19·87	2		,,	,,	875·1
19·71	2		,,	,,	876·2
18·66	2		,,	,,	883·8
17·05	2		,,	,,	895·5
16·27	4		,,	,,	901·1
15·83	2		,,	,,	904·3
14·73	3		,,	,,	912·3
13·64	4		,,	,,	920·2
12·22	3		,,	,,	930·4

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
3711·68	3		1·59	7·6	26934·4
10·32	3		,,	,,	944·2
08·73†	4	3708·79	,,	,,	955·8
07·35	3		,,	,,	965·8
05·57	2		,,	,,	978·8
02·67	4	3702·63	,,	,,	999·9
02·33	2		,,	,,	27002·4
01·67	2		,,	,,	007·2
00·15	3		,,	,,	018·3
3698·69	3		,,	,,	029·0
96·18	3	3696·17 Fe	,,	,,	047·3
95·09	7		,,	,,	055·4
93·52	4		,,	,,	066·8
92·79	4	3692·79 Fe	,,	,,	072·2
92·24	3		,,	,,	076·2
90·72	5		,,	,,	087·4
90·30	2		,,	,,	090·5
89·13	4		,,	,,	099·1
88·45	4		,,	,,	104·1
88·12	2		,,	,,	106·5
87·12	2		,,	,,	113·8
86·72	4		,,	,,	116·0
86·27	4		,,	,,	120·1
84·48	3		,,	,,	133·3
82·12	2		,,	7·7	150·6
81·88	4		,,	,,	152·3
81·69	3		,,	,,	153·7
80·85 80·75	7	3680·80	,,	,,	159·8 160·7
80·36	2		,,	,,	163·5
79·39	3		,,	,,	170·7
77·83	4	3677·83 77·76 Fe	,,	,,	182·2
76·40	4		,,	,,	192·8
76·15	3	3676·11 Fe	,,	,,	194·6
75·54	4		,,	,,	199·2
73·38	3		,,	,,	215·1
72·97	6		,,	,,	215·2
69·50‡	5	3669·54	,,	,,	244·0
68·63	3		,,	,,	250·4
66·87	4	3666·91 Fe	,,	,,	264·5
64·98‡	6	3664·97	,,	,,	277·7
64·45	4		,,	,,	281·5
63·83	2		,,	,,	286·1
63·14	4		,,	,,	291·3
61·91	4		,,	,,	300·4
61·24	3		,,	,,	305·5
61·08	4		,,	,,	306·7
59·51	7		,,	,,	318·4
58·50	2		,,	,,	325·9
57·53	5	3657·56 Fe	,,	,,	333·1
55·21	3		,,	,,	350·5
54·73	4n	3654·81 Fe 54·74 Ti 54·6 Cu	,,	,,	354·2

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
3653·75	2		1·59	7·7	27361·4
51·48	4		,,	,,	378·4
50·75	2		,,	,,	383·9
49·61	3		,,	,,	392·5
48·75	4	3649·65 Fe	,,	,,	398·9
47·03	2		,,	,,	411·9
42·37	4		,,	,,	446·9
41·16	4		,,	,,	456·0
41·08	4		,,	,,	456·7
40·76	4		,,	,,	459·1
38·72	3		,,	7·8	474·4
38·57	3 also V		,,	,,	475·5
38·35	5		,,	,,	477·2
37·68	4	3637·69	,,	,,	482·2
35·77	3		,,	,,	496·7
35·57†	5	3635·61 Ti, Fe	,,	,,	498·2
35·30	4	3635·34 Ti, Fe	,,	,,	500·2
29·45	5		,,	,,	544·6
28·80	3		,,	,,	549·5
28·50	2		,,	,,	551·7
26·33‡	5 also Fe	3626·33	,,	,,	568·3
24·77	3		,,	,,	580·2
24·60	6		,,	,,	581·4
23·36	4	3623·36 Fe	,,	,,	589·4
17·01	4		,,	,,	639·3
15·91	3		,,	,,	647·7
15·32†	5	3615·34	,,	,,	652·2
14·87	2		,,	,,	655·7
14·42	6		,,	,,	659·2
13·94	3		,,	,,	662·8
13·80	3		,,	,,	663·9
13·55	4		,,	,,	665·8
12·62	4		,,	,,	672·9
12·15	4		,,	,,	676·5
10·80	2		,,	,,	686·9
08·52	4		,,	,,	704·4
07·56	2		,,	,,	711·8
05·19	2		,,	,,	729·0
04·73	3		,,	,,	733·5
04·24	4		,,	,,	737·3
03·86	3	3603·92 Ti 03·83 Cr	,,	,,	740·2
03·10	5		,,	,,	746·1
00·04	3		,,	,,	769·7
3599·05	4		,,	,,	777·3
96·54	2		,,	,,	796·7
95·87	4		,,	,,	801·9
95·71	4		,,	,,	803·1
94·73	2		,,	7·9	810·6
91·55	3		,,	,,	835·2
90·90	4		,,	,,	840·3
90·47	2		,,	,,	843·6
89·10	4	3589·05	,,	,,	854·2
87·02	4		,,	,,	870·4
85·74	2		,,	,,	880·4

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
3584·42	3		1·59	7·9	27890·6
83·30	8		,,	,,	899·3
82·03	7		,,	,,	909·2
81·15	2		,,	,,	916·1
80·70	4		,,	,,	919·6
76·35	3		,,	,,	953·5
75·88	8		,,	,,	957·2
75·78	3		,,	,,	958·0
74·63	3		,,	,,	967·0
74·05	5	3573·97 Fe	,,	,,	971·5
71·42	3		,,	,,	992·1
70·82	5		,,	,,	996·9
70·63	3		,,	,,	998·3
66·91	2		,,	,,	28027·6
66·57	2		,,	,,	030·2
66·20	4		,,	,,	033·1
64·45	3		,,	,,	046·9
63·91	4		,,	,,	051·2
63·30‡	5	3563·30	,,	,,	055·9
62·26	4		,,	,,	064·1
60·28†	4	3560·28	,,	,,	079·7
59·42	2		,,	,,	086·5
58·25	6	3558·21	,,	,,	095·7
57·63	2		,,	,,	100·7
55·58	3		,,	8·0	116·7
54·35	4		,,	,,	127·1
52·57	2		,,	,,	140·6
51·12	3		,,	,,	152·1
48·88	2		,,	,,	169·4
48·05	2		,,	,,	176·5
47·57	2		,,	,,	180·3
43·27	2		,,	,,	214·5
42·92	2		,,	,,	217·3
42·32	5		,,	,,	222·0
29·62	2		,,	,,	243·6
39·07	3		,,	,,	248·0
37·41	6		,,	,,	261·2
34·83	3n		,,	,,	281·9
31·44	2		,,	,,	309·0
26·08	2		,,	,,	352·1
25·11	4		,,	,,	359·9
24·76	4		,,	,,	362·7
22·52	3		,,	,,	380·8
21·56	5		,,	,,	388·5
21·32	3		,,	,,	390·4
21·17	3		,,	,,	391·6
18·35	4		,,	,,	414·4
17·70	4		,,	,,	419·6
14·93	2		,,	,,	442·1
13·86	3		,,	,,	450·7
10·93	3		,,	,,	474·5
08·26	5		,,	8·1	496·2
07·45	2		,	,,	502·6
07·16	2		,,	,,	505·0
05·45	4		,,	,,	518·9

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MOLYBDENUM (ARC SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Fraunhofer Lines (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
3504·55	5	3504·57 V 04·56 Fe	1·59	8·1	28526·2
3498·21	2		,,	,,	578·0
93·49	4		,,	,,	616·5
92·98	2		,,	,,	620·8
92·05	2		,,	,,	628·4
91·92	2		,,	,,	629·4
90·42	2		,,	,,	641·7
84·05	4		,,	,,	694·1
82·55	4		,,	,,	706·5
81·95	3		,,	,,	711·4
80·26	3		,,	,,	725·4
79·60	4		,,	,,	730·8
76·15	4	3476·07 Cu	,,	,,	759·3
75·19	4		,,	,,	767·2
71·09	3		,,	,,	801·2
69·80	2		,,	8·2	811·9
69·39	4		,,	,,	815·2
68·70	2		,,	,,	821·0
68·02	4		,,	,,	826·7
67·13	3		,,	,,	834·1
66·98	4		,,	,,	835·3
65·81	3		,,	,,	845·1
63·78	3		,,	,,	862·0

‡ Certainly coincident with Fraunhofer lines.
† Not coincident with Fraunhofer lines.

CALCIUM (SPARK SPECTRUM).

Eder and Valenta, 'Denkschr. k. Akad. Wissensch. Wien,' lxviii. 1898.
Exner and Haschek, 'Sitzber R. Akad. Wissensch. Wien,' cvi. 1897.

Wave-length		Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek		λ+	$\frac{1}{\lambda}$−	
6499·9		8	1·91	4·5	15380·5
93·9		10	,,	,,	394·4
71·9		8	1·90	,,	447·0
62·8		10	,,	,,	468·8
49·99		8	,,	,,	499·5
39·4		10	1·89	,,	525·0
6169·9		5	1·82	4·8	16203·0
69·4		5	,,	,,	204·3
66·8		5	1·81	,,	211·2
62·5		10	,,	,,	222·5
22·5		10	1·80	,,	328·5
02·99		8	,,	,,	380·6
5857·7		8s	,,	5·0	17066·3
5603·009		5s	1·53	4·9	842·7
01·475		5s	,,	,,	847·5

Seen but not measured

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CALCIUM (SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek		$\lambda+$	$\frac{1}{\lambda}-$	
5598·681		5s	1·53	4·9	17856·5
94·632		6s	,,	,,	869·4
90·324		4s	1·52	,,	883·1
88·948		6n	,,	,,	887·6
82·167		4s	,,	,,	909·3
13·120		2b^r	1·50	,,	18133·7
5349·619		5s	1·46	5·1	687·8
5270·463		5s	1·44	5·2	968·5
65·720		5s	,,	,,	985·6
64·402		3s	,,	,,	990·3
62·365		3s	,,	,,	997·7
61·863		3s	,,	,,	999·5
5188·977		2s	1·42	5·3	19266·3
5041·920		1n	1·38	5·4	828·3
4878·360		4s	1·33	5·6	20493·1
4847·2		1n	,,	5·7	624·8
4586·086		6b^v	1·26	6·0	21799·1
81·618		5s	,,	,,	820·3
78·780		4s	1·25	,,	833·9
27·183		4b^v	1·24	6·1	22082·7
4481·34	4481·7	2n Mg?	1·23	6·2	308·6
67·929		1n	1·22	,,	375·5
66·625		1n	,,	,,	382·1
56·786		3s	,,	,,	431·5
56·057	56·06	7s	,,	,,	435·2
54·919	54·93	7n	,,	,,	440·9
44·087		1	,,	,,	495·6
42·963		1	,,	,,	501·3
35·838	35·84	6s	,,	,,	537·4
35·124	35·12	6n	,,	,,	541·1
25·616	25·62	8b	1·21	6·3	589·4
4355·467		3b^v	1·19	6·4	953·2
33·932		1	,,	,,	23067·3
30·313		2	,,	,,	086·6
18·798	4318·79	8	1·18	,,	148·2
14·148		2	,,	,,	173·1
10·585		1	,,	,,	192·3
07·864	07·92	5	,,	6·5	213·4
02·676	02·70	9	,,	,,	234·8
4299·133	4299·14	8	,,	,,	254·0
89·534	89·55	8	,,	,,	306·1
83·125	83·18	8	,,	,,	340·9
78·018		2	1·17	,,	368·8
77·403		1	,,	,,	372·2
71·760		1b	,,	,,	403·1
40 515	40·55	2n	1·16	6·6	575·4
38·587		1n	,,	,,	586·2
26·870	26·88	8r	,,	,,	651·6
4130·98		1n	1·13	6·8	24200·5
27·96		1n	,,	,,	218·2
23·39		1n	,,	,,	245·1
4098·876		2b^v	,,	,,	390·0
95 243		2b^v	,,	6·9	411·7
57·980		3s	1·12	,,	635·9
3979·208		r 'ghost'?	1·10	7·1	25123·5

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CALCIUM (SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek		$\lambda+$	$\frac{1}{\lambda}-$	
3973·908	3973·87	2s	1·09	7·1	25157·0
68·638	68·62	10r	,,	,,	190·5
57·960		r 'ghost'?	,,	,,	258·4
57·232	57·23	4s	,,	,,	263·1
49·101	49·03	3s	,,	7·2	315·0
33·803	33·81	10r	1·08	,,	413·5
23·345		10r 'ghost'?	,,	,,	481·2
15·388		1	,,	,,	533·1
09·980		1	,,	,,	568·4
05·691		4s	,,	7·3	596·4
3856·153		2b	1·06	,,	925·3
26·506		4s	,,	,,	26126·2
3759·419		3s	1·04	7·5	592·4
47·151		4b	,,	,,	679·4
37·090	3737·25	10b^{v}	1·03	,,	751·3
16·193		2b^{v}	,,	,,	901·7
06·190	06·25	10b^{v}	,,	7·6	974·3
3696·429		2b^{v}	1·02	,,	27045·5
85·317		3s	,,	,,	127·1
53·606		2	1·01	7·7	362·5
44·466	3644·53	8	,,	,,	431·1
30·812	30·8	6b^{r}	,,	7·8	534·3
24·162	24·1	5b^{r}	,,	,,	584·8
01·957		2b	1·00	,,	754·9
3594·259		1s	,,	7·9	814·2
87·156		4b	,,	,,	869·3
35·60		2s	0·98	8·0	28275·7
10·97		4s	,,	,,	474·2
05·00		5s	,,	8·1	514·4
3487·87		2b^{v}	0·97	,,	662·7
74·96		2b^{v}	,,	,,	769·2
56·58		2s	0·96	8·2	922·1
44·53		3s	,,	,,	29023·3
3387·99		3s	0·95	8·4	507·6
72·930		6s	0·94	,,	639·4
61·374		6s	,,	,,	741·4
49·568		6s	,,	8·5	846·1
49·199		4s	,,	,,	849·4
35·30		2s	0·93	,,	973·8
32·26		2n	,,	,,	30001·2
29·60		3s	,,	,,	025·1
23·09		6s	,,	8·6	083·9
3278·74		2s	0·92	8·7	490·8
61·70		4s	,,	,,	650·2
48·71		3s	0·91	8·8	772·7
42·11		3s	,,	,,	835·3
39·15		3s	,,	,,	863·5
36·70		5s	,,	,,	886·9
34·68		6s	,,	,,	906·2
24·42		1s	,,	,,	31004·5
23·00		2s	,,	,,	018·2
18·45		1	0·90	,,	062·1
17·05		1	,,	,,	075·6
3181·409	3181·51	8b^{v}r	0·89	8·9	422·9
79·447	79·60	10b^{v}r	,,	9·0	443·0

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CALCIUM (SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek		$\lambda+$	$\frac{1}{\lambda}-$	
3170·2		1n	0·89	9·0	31534·8
59·013	59·11	10b"r	,,	,,	646·5
03·92		2s	0·88	9·2	32208·1
3092·84		8s	0·87	,,	323·5
88·11		4s	,,	,,	373·1
82·21		8s	,,	9·3	435·0
78·67		3s	,,	,,	472·3
75·39		2s	,,	,,	506·9
73·06		1s	,,	,,	531·6
66·40		3n	,,	,,	602·2
09·32	3009·29	3s	0·85	9·5	33220·6
06·98	06·95	4s	,,	,,	246·5
2999·74		2	,,	,,	326·7
97·2		1	,,	9·6	354·9
95·08	2995 04	3s	,,	,,	378·5
36·83		4n	0·83	9·8	34040·5
28·92		4n	,,	,,	132·5
2816·44		2n	0·80	10·3	35495·5
2660·53		4	0·77	10·9	37575·6
2575·22		3	0·75	11·3	38820·3
68·09		3	,,	11·4	928·0
2398·73		2n	0·71	12·3	41676·4
73·24		2	0·70	12·5	42124·0
13·02		1	0 69	13·0	43220·5
09·20		1	,,	,,	292·0
2290·09		1	,,	13·1	653·3
75·44		2	0·68	13·3	934·2
59·5		½n	,,	13·4	44244·2
08·95		2	0·67	13·8	45256·6
00·5		½n	,,	13·9	430·3
2198·03		2	,,	,,	481·5
33·0		½	0·66	14·1	46868·2
31·2		½	0·65	14·5	907·4
23·0		½	,,	14·6	47088·6
13·01		1	,,	14·7	311·2
03·47		1	,,	14·8	525·7
2099·87		1	,,	,,	607·2
86·64		1	,,	14·9	909·0
81·53		1	,,	15·0	48026·6

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Scandium (Ultra-violet Spark Spectrum).

Exner and Haschek, 'Sitzber. kais. Akad. Wissensch. Wien,' cix. 1900.

Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
		$\lambda +$	$\frac{1}{\lambda} -$	
4744·02	2	1·30	5·8	21073·4
41·25	2	,,	,,	085·7
37.86	1	,,	,,	100·8
34·30	1	,,	,,	116·6
29·40	1	1·29	,,	138·5
4698·50	1	,,	5·9	277·5
70·64	7	1·28	,,	404·4
4574·17	1n	1·25	6·0	855·7
4431·57	3	1·22	,,	22559·1
20·87	2	1·21	,,	613·9
4315·85	15	,,	6·2	646·5
00·64 *	20	,,	6·3	716·6
85·01	4	1·20	,,	797·7
74·70 *	20	,,	,,	852·4
59·22	1	,,	6·4	933·5
54·80	3	1·19	,,	956·8
25·24 *	20	,,	,,	23113·6
21·01 *	20	,,	,,	136·3
14·32	30	1·18	,,	172·2
05·94	6	,,	6·5	220·1
4294·98	5	,,	,,	276·5
80·05	1	1·17	,,	357·7
47·02 *	100	,,	6·6	539·3
38·22	1	1·16	,,	588·2
32·12	1 Nb ?	,,	,,	622·2
29·98	1	,,	,,	634·2
4082·60 *	3	1·12	6·9	24487·3
68·8	2b	,,	,,	570·4
61·4	2b	,,	,,	615·1
54·70 *	3	1·11	,,	655·8
47·96	2	,,	7·0	696·8
23·86 *	8	,,	,,	844·7
20·56 *	8	,,	,,	862·7
14·68	8	1·10	,,	901·8
3996·76 *	2	,,	7·1	25013·2
89·21	1	,,	,,	060·5
88·13	1 Yb ?	,,	,,	067·3
44·9	1n	1·09	7·2	346·8
23·60	1	1·08	,,	478·6
12·05 *	6	,,	,,	553·2
07·69	6	,,	7·3	583·3
3678·65	3n r	1·02	7·7	27176·2
76·82	1	,,	,,	189·7
75·42	1	,,	,,	200·0
66·69	3	,,	,,	264·0
64·37	1	,,	,,	282·1
51·96 *	20	1·01	,,	375·0
45·46 *	15	,,	,,	423·7
42·93 *	50	,,	,,	442·7
30·86	100	,,	7·8	533·0
28·35	1n	,,	,,	552·9

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SCANDIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
		$\lambda+$	$\frac{1}{\lambda}-$	
3624·77	1n	1·00	7·8	27579·2
19·97	1 Yb ?	,,	,,	618·8
13·96 *	100	,,	,,	665·4
03·1	1b	,,	,,	746·0
3590·67	10	,,	7·9	842·0
89·82	10	,,	,,	848·6
81·15	20	,,	,,	915·1
76·52 *	30	0·99	,,	953·1
72·71 *	50	,,	,,	982·1
67·86	20	,,	,,	28020·1
58·72	20	,,	,,	092·1
35·88	15	0·98	8·0	274·2
3457·62	1	0·96	8·2	896·7
35·67	1	,,	,,	29089·7
29·59	1	,,	8·3	149 7
3394·55	1n	0·95	8·4	449·6
85·6	1b	,,	,,	528·5
83·81	1	,,	,,	544·1
79·5	3nr	,,	,,	581·8
78·5	1nr	,,	,,	590·5
72·30	10	0·94	,,	644·9
69·10	10	,,	,,	675·1
62·09	8	,,	,,	735·0
61·45	8	,,	,,	740·7
59·83	8	,,	,,	759·8
53·88 *	20	,,	8·5	807·7
52·19	2	,,	,,	822·7
43·5	3b	,,	,,	900·3
31·4	2b	0·93	,,	30008·8
17·9	1b	,,	8·6	148·2
17·25	1n	,,	,,	145·9
13·0	3b	,,	,,	184·6
12·0	2b	,,	,,	193·7
3289·50	1 Yb ?	0·92	8·7	395·6
73·76	2	,,	,,	536·2
70·05	2	,,	,,	571·8
55·79	1	,,	,,	705·8
51·44	1	0·91	8·8	746·8
3199·6	1b	,,	8·9	31245·0
91·2	1b	,,	,,	327·2
39·98	2n	,,	9·1	838·2
33·32	2n	0·88	,,	899·7
30·49	1 Nb ?	,,	,,	934·6
28·48	1n	,,	,,	955·1
26·2	1b	,,	,,	978·6
08·70	1n	,,	9·2	32158·3
3082·80	1	0·87	9·3	428·7
65·32	5n	,,	,,	613·6
60·7	1n	0·86	,,	663·)
53·12	4n	,,	9·4	744·)
45·88	3n	,,	,,	821·8
40·15	2n	,,	,,	883·7
21·14	1	0·85	9·5	090·6
20·70	1	,,	,,	095·4
19·42	1	,,	,,	33109·5

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SCANDIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
		$\lambda +$	$\frac{1}{\lambda} -$	
3015·46	1	0·85	9·5	33153·0
2989·20	3n	,,	9·6	444·2
80·91	1	0·84	,,	548·4
80·0	1b	,,	,,	547·5
74·17	1 Nb ?	,,	,,	613·2
13·1	1n	0·83	9·9	34308·2
2871·1	1b	0·82	10·1	809·9
66·2	1b	,,	,,	860·0
59·5	1b	0·81	,,	961·1
58·40	1	,,	,,	974·2
26·88	3n	,,	10·2	35364·5
22·4	3b	0·80	10·3	420·5
19·75	2n	,,	,,	453·8
01·6	1b	,,	,,	683·6
2790·94	1n	,,	10·4	819·8
89·4	2b	,,	,,	839·5
82·6	1b	0·79	,,	927·1
34·12	7	0·78	10·6	36543·7
2699·14	10	,,	10·8	37027·4
84·3	1b	0·77	,,	242·7
76·15	1n	,,	10·9	346·4
67·7	1b	,,	,,	474·5
11·4	2b	0·76	11·1	38282·5
2563·30	4	0·74	11·4	991·2
62·65	3	,,	,,	39010·7
60·39	6	,,	,,	029·8
55·91	4	,,	,,	112·4
52·49	8	,,	,,	166·0
45·31	4	,,	11·5	266·9
2400·44	1	0·71	12·3	41646·7
2363·95	1b	0·70	12·6	42289·5
2299·25	1n	0·69	13·1	43466·6
88·20	1n	,,	,,	675·6
73·21	3	0·68	13·3	963·6
51·94	1n	,,	13·4	44891·7
32·98	1n	,,	13·6	769·6

* Rowland 4400·555, 4374·628, 4325·152, 4320·907, 4246·696 (Y?), 4082·589 Sc, Fe, Ti; 4054·714, 4023·834, 4020·547, 3996·682, 3911·963, 3651·940, 3645·475 Sc ?, 3642·912. 3613·947, 3576·527, 3572·712, 3553·875, also 5672·047 occur in Rowland's list of solar lines.

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Indium (Ultra-violet Spark Spectrum).

Exner and Haschek, 'Sitzber. kais. Akad. Wissensch. Wien,' cviii. (2), 1899.

Wave-length	Intensity and Character	Previous Observations (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
4511·55	50r	4511·44 K and R	1·24	6·1	22159·2
4375·13	2		1·20	6·3	850·1
09·72	1		1·18	6·4	23197·0
4177·69	2		1·15	6·7	930·0
02·01	50r	4101·87 „	1·13	6·8	24371·5
3835·2	3b		1·06	7·3	26067·0
3774·49	1		1·04	7·4	486·2
10·45	2		1·03	7·6	943·3
3633·27	1		1·01	7·8	27515·6
11·20	1		1·00	„	683·8
10·60	1		„	„	688·4
3519·33	1 Tl?		0·98	8·0	28406·5
3262·48	1 Sn		0·92	8·7	30642·8
58·64	3	3258·66 „	0·91	„	679·0
56·22	8r		„	„	701·8
3187·15	1n		0·90	8·9	31367·0
75·17	1 Sn		„	9·0	485·5
3039·45	4n r	3039·46 „	0·86	9·4	32891·3
34·23	1n Sn		„	„	947·9
08·30	10		„	9·5	33231·9
2983·51	8n		0·85	9·6	508·1
41·39	10		0·84	9·8	987·7
32·73	1	2932·71 „	0·83	„	34088·1
2890·35	4		0·82	10·0	587·8
40·11	1 Sn		0·81	10·2	35199·6
2754·03	1n	2753·97 „	0·79	10·5	36299·9
14·1	1n	14·05 „	0·78	10·7	833·9
10·39	2b	10·38 „	„	10·9	884·4
2658·7	1b Sn		0·77	11·2	37601·5
02·0	1b	2601·84 „	0·76	11·4	38420·8
2560·05	1b	2560·25 „	0·74	12·1	39050·3
2429·52	1n Sn	2429·76 „	0·72	12·7	41148·3
2350·84	1		0·70	13·0	42525·3
06·18	5		0·69	13·3	43348·7
2265·08	2		0·68	„	44135·3

Beryllium (Ultra-violet Spark Spectrum).

Exner and Haschek, 'Sitzber. kais. Akad. Wissensch. Wien,' cviii. (2), 1899.

Wave-length	Intensity and Character	Previous Observations (Rowland)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
4572·88	1	4572·9 Thalén	1·25	6·0	21867·1
3321·51	3	3321·5? Hartley	0·93	8·6	30098·2
21·23	3		„	„	100·7
3131·20	15	3130·2 „	0·88	9·1	31927·5
30·56	20r		„	„	935·9
2650·71	7 double	2650·2 „	0·76	1·0	37714·7
2494·84	3 r	2493·9 „	0·73	1·7	40071·0
94·69	3 r		„	„	073·5
2348·72	3		0·70	2·7	42562·7
48·58	1		„	„	566·2

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Lithium (Spark Spectrum).

Eder and Valenta, 'Denkschr. kais. Akad. Wissensch. Wien,' lxvii. 1898.
Exner and Haschek, 'Sitzungsber. kais. Akad. Wissensch. Wien, cvi. 1897.

Wave-length		Intensity and Character	Previous Observations (Kayser and Runge) (arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek			$\lambda+$	$\frac{1}{\lambda}-$	
6708·2		10	6708·2	1·82	4·0	14903·1
6103·77		10	6103·77	1·66	4·4	16378·9
4972·11		4	4972·11	1·36	5·5	20106·7
	4603·10	2n r		1·26	6·0	21718·5
4602·46		10b'r	4602·37	,,	,,	21721·5
4273·52		4n	4273·44	1·17	6·5	23393·4
4132·57		6b	4132·44	1·14	6·8	24191·2
3985·90		1n	3985·94	1·10	7·1	25081·3
3232·798	3232·91	5n	3232·77	0·91	8·8	30924·1
	2815·55	1		0·80	10·3	35506·7
2741·57		2	2741·39	0·78	10·6	36464·9

Lithium (Oxyhydrogen Flame Spectrum).

Ramage, 'Proc. Royal Soc.' lxxi. 1902, p. 164.

Wave-length	Intensity and Character	Previous Observations (Kayser and Runge) (arc)	Reduction to Vacuum		Oscillation Frequency
			$\lambda+$	$\frac{1}{\lambda}-$	
6708·0	10 P2	6708·2	—	—	—
6103·84	9 A3	6103·77	1·66	4·4	16378·7
4971·98	2 B4	4972·11	1·36	5·5	20107·2
4603·07	7 A4	4602·37	1·26	6·0	21718·6
4273·34	1 B5	4273·44	1·17	6·5	23394·4
4132·93	5 A5	4132·44	1·14	6·8	24189·1
3985·86	1 B6	3985·44	1·10	7·1	25081·6
3915·59	3 A6	3915·2	1·08	7·2	25531·7
3795·18	2 A7	3794·9	1·05	7·4	26341·8
3719·0	1 A8	3718·9	1·03	7·6	26881·3
3232·82	4 P3	3232·77	0·91	8·8	30923·9
2741·43	1 P4	2741·39	0·78	10·6	36466·7

Thallium (Ultra-violet Spark Spectrum).

Exner and Haschek, 'Sitzungsber. kais. Akad. Wissensch. Wien,' cviii. 1899.
Eder and Valenta, 'Denkschr. kais. Akad. Wissensch. Wien,' lxviii. 1899.
Cornu, 'C. R.,' c. 1885, p. 1181.

Wave-length		Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
Exner and Haschek	Eder and Valenta			$\lambda+$	$\frac{1}{\lambda}-$	
3775·89		20r	3775·87 K. and R.	1·04	7·4	26476·4
3529·54		10	3529·58 ,,	0·98	8·0	28324·3
19·35		20r	19·39 ,,	,,	,,	406·3
13·42		1n		,,	,,	454·3
3456·50		2n		,,	8·1	922·9
3229·90		2b	3229·88 ,,	0·91	8·8	30955·7

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THALLIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
Exner and Haschek	Eder and Valenta			$\lambda +$	$\frac{1}{\lambda} -$	
3091·88		1b		0·88	9·2	32333·6
2921·7		1b	2921·63 K. and R.	0·83	9·8	34216 8
18·47		1n	18·43 „	„	9·9	254·6
2768·00	2768·00	6nr	2767·97 „	0·79	10·5	36116·7
	2740·01	3nr		„	„	485·6
	34·08	1n		0·78	„	564·8
	18·08	½n		„	10·7	780·0
	10 90	4b	2710·77 „	„	„	877·4
2709·3	09·34	3br	09·33 „	„	„	899·2
	00·34	2n	00·3 „	„	10·8	37021·6
	2670·97	1		0·77	10·9	428·5
	69·90	2n		„	„	443·6
2665·8	65·74	3n	2665·67 „	„	„	502·2
	14·22	1s	09·86 „	0·76	11·0	38241·3
	09·14	2	09·08 „	„	„	315·9
	2585·90	1n	2585·68 „	0·75	11·3	658·7
2580·30	80·29	3nr	80·23 „	„	„	743·9
	44·33	1		0·74	11·5	39291·6
2530·94	30·89	5b		„	„	515·8
	13·58	1		0·73	11·6	772·3
	2478·67 Fe	4		„	11·8	40332·4
	69·27	5		0·72	11·9	485·9
2452·04	52·04	4n		„	12·0	770·4
	45·61	2		„	„	877·6
	33·65	1n		„	12·1	41078·5
	2394·72	3s		0·71	12·4	746·2
	79·68	10r	2379·66 „	„	12·5	42010·0
	65·00	3		0·70	12·6	270·6
	62·30	½n	2362·16 „	„	„	319·0
	41·82	½		„	12·7	689·1
	16·14	4	2316·01 „	0·69	12·9	43162·4
	10·50	½		„	13·0	267·7
2298·25	2298·25	7s		„	13·1	498·3
	88·07	2		„	13·2	691·8
	85·95	1		„	„	732·3
	65·05	3s		0·68	13·3	44135·8
	37·83	3r	2237·91 „	„	13·6	652·5
	30·3	1n		„	„	823·4
	15·9	½		0·67	13·8	45114·6
	10·79	3	2210·80 „	„	„	218·9
	09·9	1n		„	„	237·1
	07·21	2b	2207·13 „	„	„	292·3
	03·79	1		„	„	362·6
	2144·50	1		0·66	14·4	46616·5
	39·44	3		„	„	726·8
Cornu						
2119·2				0 65	14·6	47173·0
05·1				„	14·8	470·8
2088 5				„	„	615·6
88·8				„	14·9	859·7
83·2				„	15·0	988·1
77·3				„	„	48124·4
72·4				0·64	15·1	238·1
69·2	2069·80	1		„	„	312·8
62·3				„	15·2	474·4

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THALLIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
Exner and Haschek	Eder and Valenta			$\lambda+$	$\frac{1}{\lambda}-$	
57·3				0·64	15·2	592·4
53·9				,,	15·3	672·6
	1964·80	1		0 62	16·2	50879·5
	1868·48	1		,,	17·4	53502·1
	62·70	1		,,	,,	668·1

POTASSIUM (OXYHYDROGEN FLAME SPECTRUM).[1]

[1] Ramage, 'Proc. Royal Soc.' lxx. 1902, p. 303.

Wave-length	Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
7697	10 P1	7701·92 Lehmann	2·08	3·5	12988·6
64	10 P1	7668·54 ,,	,,	,,	13044·5
6939	8 B3	6938·8 Kayser and Runge	1·88	3·9	14407
13	7 B3	11·2 ,, ,,	18·7	,,	462
5832·25	6 A4	5832·23 ,, ,,	1·59	4·7	17141·3
12·53	5 A4	12·54 ,, ,,	1·58	,,	199·5
02·12	7 B4	02·01 ,, ,,	,,	,,	230·8
5782·74	6 B4	5782·67 ,, ,,	,,	4·9	288·1
5359·96	4 A5	5359 88 ,, ,,	1·46	5·1	18651·8
43·38	2 A5	43·35 ,, ,,	,,	,,	709·6
40·17	3 B5	40·08 ,, ,,	,,	,,	720·9
23·68	2 B5	23·55 ,, ,,	1·45	,,	778·9
5112·76	2 A6	5112·68 ,, ,,	1·40	5·4	19553·1
5099·83	1 B6	5099·64 ,, ,,	1·39	,,	602·7
97·64	1 A6	97·75 ,, ,,	,,	,,	611·1
85·07	1 B6	84·49 ,, ,,	,,	,,	659·4
4965·61	1 A7	4965·5 ,, ,,	,,	,,	20132·5
57	1 B7	56·8 ,, ,,	1·38	,,	167
51·46	1 A7	52·2 ,, ,,	,,	,,	190·1
4870	1 A8	4870·8 Liveing and Dewar	,,	,,	528
62	1 B8	63·8 ,, ,,	,,	,,	562
57	1 A8	56·8 ,, ,,	,,	,,	383
29	1		,,	,,	702
03	1 A9	03·6 ,, ,,	,,	,,	814
01	1 B9		,,	,,	823
4798	1	4796·8 ,, ,,	,,	,,	836
67	1		,,	,,	972
60	1 A10	59·8 ,,	,,	,,	21002
4642·35	2	} 4642 Hartley and Ramage	,,	,,	534·4
38·6	1		,,	,,	551·8
4047·39	9 P2	4047·36 Kayser and Runge	1·11	7·0	24700·3
44·33	10 P2	44·29 ,, ,,	,,	,,	719·0
3447·56	3 P3	3447·49 ,, ,,	0·96	8·2	28997·8
46·55	4 P3	46·49 ,, ,,	,,	,,	29006·3
Present	1 P4	3217·76 ,, ,,	,,	,,	31068·7
3217·36	2 P4	17·27 ,, ,,	0·90	8·8	972·7

The lines of the principal series are marked 'P,' those of the first subordinate series 'A,' and those of the second subordinate series 'B.'

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Rubidium (Oxyhydrogen Flame Spectrum).

Ramage, 'Proc. Royal Soc.' lxx. p. 305.

Wave-length	Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
	P1	7950·46 Lehmann.	2·15	4·3	
7799	10 P1	7805·98 „	2·11	„	
6306·8	1		1·71	„	15851·3
6299·19	9 A4	6298·7 Kayser and Runge	„	„	870·5
06·74	8 A4	06·7 „ „	1·69	4·4	16106·8
6160·04	5 B4	6159·8 „ „	1·68	„	228·9
6071·04	4 B4	6071·2 „ „	1·65	4·5	466·8
5724·62	8 A5	5724·41 „ „	1·56	4·7	17463·2
5654·16	3 B5	5654·22 „ „	1·54	4·8	680·9
48·19	7 A5	48·18 „ „	„	„	699·6
5579·5	2 B5		1·52	4·9	918·1
5432·05	6 A6	5431·83 „ „	1·48	5·1	18403·9
5391·3	1 B6		1·47	„	543·0
63·15	5 A6	5362·94 „ „	„	„	640·3
22·83	1 B6		1·45	„	781·5
5260·51	4 A7	5259·8 „ „	1·44	5·2	19004·0
34·6	1 B7		1·43	„	098
5195·76	3 A7	5194·8 „ „	1·42	5·3	240·7
65·35	2		„	„	354·1
51·20	2 A8		1·41	„	407·2
32	1 B8		1·40	„	480
5089·5	1 A8		1·39	5·4	642·5
76·3	1 A9		„	„	698·6
37	1		1·38	„	847
23	1 A10	5021·8 „ „	1·37	5·5	902
17	1 A9		„	„	926
4983	1 A11		1·36	„	20062
67	1		„	„	127
4215·68	9 P2	4215·72 „ „	1·15	6·6	23714·4
02·04	10 P2	01·98 „ „	„	„	791·4
3591·86	3 P3	3591·74 „ „	1·00	7·9	27832·8
87·27	4 P3		„	„	868·4
3350·98	1 P4	3351·03 „ „	0·94	8·5	29833·5
48·84	2 P4	48·86 „ „	„	„	852·6
3229·26	1 P5		0·91	8·8	30958·0
28·18	1 P5		„	„	968·4

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Cæsium (Oxyhydrogen Flame Spectrum).

Ramage, 'Proc. Royal Soc.' lxx. 1902, p. 304.

Wave-length	Intensity and Character	Previous Observations	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
6984	6		1·90	3·9	14314
74	9 A4	6973·9 Kayser and Runge	1·89	„	335
6869	2		1·86	„	554
29	2		„	4·0	639
6722	9 A4	6723·6 „ „	1·83	„	873
6630	2		1·81	4·1	15079
6590	8 B4		1·79	„	171
6472	2		1·76	4·2	447
33	2		1·75	„	540
6354	8 B4		1·73	4·3	733
6217·6	2		1·69	4·4	16078·7
13·33	8 A5	6213·4 „ „	„	„	089·7
6034·43	4 B5		1·64	4·8	566·7
10·59	8 A5	6010·6 „ „	„	„	632·4
5847·86	2		1·59	„	17095·6
45·31	8 A6	5845·1 „ „	„	„	102·7
39·33	2 B5		„	„	120·2
5746·37	1 B6		1·57	„	397·2
5664·14	7 A6	5664·0 „ „	1·54	„	649·7
35·44	5 A7	35·1 „ „	„	„	739·6
5574·4	1 B7	5573·1 Lecoq de Boisbaudran	1·52	4·9	933·9
68·9	1 B6		„	„	951·6
03·1	3 A8	01·9 ? „ „	1·50	5·0	18166·2
5466·1	4 A7	5465·8 Kayser and Runge	1·49	„	289·2
14·4	1 A9		1·48	„	463·8
07·5	1 B7		„	„	487·3
5351	1 A10		1·46	5·1	682
41·15	3 A8		„	„	717·0
04	1 A11		1·45	„	848
5256·96	1 A9	5257·8 Lecoq de Boisbaudran	„	5·2	19016·8
09	1		1·42	„	192
5199	1 A10		„	5·3	228
54	1 A11		„	„	396
4593·30	8 P2	4593·34 Kayser and Runge	1·26	6·0	21764·8
55·46	10 P2	55·44 „ „	1·25	„	945·6
3888·75	2 P3	3888·83 „ „	1·07	7·3	25707·9
76·31	4 P3	76·73 „ „	„	„	790·4
3617·49	1 P4	3617·08 „ „	1·01	7·8	27635·7
11·70	2 P4	11·84 „ „	1·00	„	680·0
3477·25	1 P5		0·97	8·1	28750·3
3398·40	1 P6		0·95	8·3	29417·3
48·72	1 P7		0·94	„	853·7
14	1 P8		0·93	8·6	30166
3287	1 P9		0·92	8·7	414

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Antimony (Ultra-violet Spark Spectrum).

Eder and Valenta, 'Denkschr. kais. Akad. Wissensch. Wien,' lxviii., 1899.
Exner and Haschek, 'Sitzungsber. kais. Akad. Wien,' cvi. 1897.

Wave-length		Intensity and Character	Previous Observations Kayser and Runge (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek			$\lambda +$	$\frac{1}{\lambda} -$	
	4693·2	2b		1·29	5·9	21301·9
	58·0	1n		1·28	„	462·5
	47·8	1n		1·27	„	509·6
	23·5	1b		„	6·0	622·6
	4599·6	1b		1·26	„	735·0
	91·9	4b		„	„	771·5
	44·8	1		1·25	6·1	996·1
	26·0	1b		1·24	„	22088·5
	06·8	1n		„	„	183·6
	4499·0	1n		1·23	„	221·1
	57·8	1b		1·22	6·2	426·4
	33·0	1b		„	„	551·9
	28·6	1b		1·21	6·3	574·2
	25·5	1b		„	„	590·0
	11·7	1b		„	„	660·5
	4378·0	2b		1·24	„	835·1
	67·0	1b		„	6·4	892·6
	52·4	10b		1·19	„	971·4
	15·0	4b		1·18	„	23168·9
	4260·3	8b		1·17	6·5	466·0
	59·5	1b		„	„	470·4
	30·0	1b		1·16	6·6	634·0
	26·9	1 Ca		„	„	651·4
	24·5	1b		„	„	664·8
	19·2	6n		„	„	694·6
	01·1	1b		1·15	„	792·1
	4195·3	4b		„	6·7	829·5
	71·0	1b		„	„	968·4
	40·7	2b		1·14	6·8	24142·0
	34·0	2b		„	„	182·8
	4058·0	6 (Pb)		1·12	6·9	635·8
	40·6	1b		1·11	7·0	739·3
	33·71	8	4033·70	„	„	784·0
	24·8	1b		„	„	838·8
	3986·1	2n		1·10	7·1	25080·2
	68·6	2 Ca		1·09	„	188·2
	64·8	2n		„	„	214·9
	60·8	4b		„	„	240·1
	33·8	2 Ca		1·08	7·2	413·5
	33·7	2b		„	„	414·2
	32·0	1n		„	„	425·2
	08·8	1b		„	7·3	576·0
	3883·3	1n		1·07	„	744·0
	50·4	6b		1·06	„	964·0
	41·4	6b		„	„	26024·9
	3772·9	2b		1·04	7·5	497·3
	66·6	1n		„	„	541·6
	54·8	1		„	„	625·1
	39·5	8b		„	„	724·0
	22·93	8	3722·92	1·03	7·6	853·0
	3692·0	1b		1·02	„	27078·0
	87·0	2b		„	„	114·7

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ANTIMONY (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Previous Observations Kayser and Runge (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek			$\lambda +$	$\frac{1}{\lambda} -$	
	3683·7	2 Pb		1·02	7·7	27138·9
	77·8	1		„	„	182·5
	75·6	1b		„	„	198·7
	68·0	1b		„	„	255·1
	55·5	1n		1·01	„	348·3
	52·0	6n		„	„	374·6
	39·8	1		„	„	466·3
	38·01	8	3637·94	„	7·8	479·8
	36·8	1		„	„	488·9
	30·0	4b		„	„	540·4
	27·5	1n		„	„	559·4
	3597·7	8b		1·00	„	787·7
	66·7	8b		0·99	7·9	28029·2
	59·5	8b		„	„	085·9
	34·0	4b		0·98	8·0	288·5
	19·7	4b		„	„	403·5
	04·8	10b		„	8·1	524·2
	3498·6	8b		0·97	„	574·8
	74·0	8b		„	„	777·2
	59·5	1b		„	8·2	897·7
	52·0	1b		0·96	„	960·5
	25·9	4b		„	8·3	29181·1
	14·7	1n		0·95	„	276·8
	03·9	2b		„	„	369·8
	00·0	1n		„	„	403·5
	3396·0	1b		„	8·4	438·0
	93·8	1b		„	„	457·1
	90·6	1b		„	„	484·9
	83·2	6	3383·24	„	„	544·2
	77·5	1b		0·94	„	599·3
	74·8	1b		„	„	614·2
	67·2	1b		„	„	689·9
	55·0	1b		„	8·5	797·8
	37·3	4b		„	„	955·8
	12·8	1n		0·93	8·6	30177·3
	04·3	2b		„	„	255·0
	3288·3	1n		0·92	8·7	402·2
	85·8	1b		„	„	425·3
	78·7	1b		„	„	491·2
	76·7	1b		„	„	509·8
	74·1	2		„	„	534·0
	67·62	10	3267·60	„	„	595·1
	55·4	1		0·91	„	709·5
	52·2	1		„	8·8	739·6
	47·7	1		„	„	782·2
	41·2	8b		„	„	844·0
	32·65	10	32·61	„	„	925·6
	3197·4	1b		0·90	8·9	31266·5
	93·7	1n		„	„	302·7
	92·8	1n		„	„	311·6
	75·2	1n		0·89	9·0	485·1
	69·4	1b		„	„	542·7
	48·2	1b		„	„	755·2
	3087·2	1b		0·87	9·2	32382·6
	67·9	1		„	9·3	586·3

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ANTIMONY (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length		Intensity and Character	Previous Observations Kayser and Runge (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek			$\lambda +$	$\frac{1}{\lambda} -$	
	3040·7	8b		0·86	9·4	32877·8
	29·90	10	3029·91	,,	,,	995·0
	24·8	1		,,	9·5	33050·5
	22·1	2b		0·85	,,	079·7
	10·1	2b		,,	,,	212·0
	2981·2	8n		,,	9·6	533·9
	66·4	6b		0·84	9·7	701·3
	23·5	1b		0·83	9·8	34195·8
	13·53	8n		,,	9·9	313·4
	2895·7	1b		0·82	,,	524·1
	91·7	4b		,,	10·0	571·7
	90·0	2b		,,	,,	592·1
	87·7	1b		,,	,,	619·6
	86·0	1b		,,	,,	640·0
	84·0	1b		,,	,,	664·1
	80·0	2b		,,	,,	712·2
	78·05	10	2878·01	,,	,,	735·7
	63·1	1b		0·81	10·1	917·1
	58·1	1		,,	,,	978·3
	57·2	1n		,,	,,	989·3
	53·3	1n		,,	,,	35037·0
	51·20	8	51·20	,,	,,	062·8
	37·5	1b		,,	10·2	232·1
	33·1	1		,,	,,	286·8
	26·9	2b		,,	,,	361·6
	19·0	1b		0·80	10·3	463·3
	13·3	1n		,,	,,	535·1
2806·80		10n		,,	,,	617·5
	02·0			,,	,,	678·4
	2797·9	1b		,,	10·4	730·7
	95·7	1		,,	,,	758·8
	90·57	8n		,,	,,	824·6
	86·2	1n		,,	,,	880·8
	75·8	1b		0·79	,,	36015·2
2769·97	70·08	8s	2770 04	,,	10·5	089·8
	64·8	1b		,,	,,	178·5
	62·2	1n		,,	,,	198·5
	41·2	1n		0·78	10·6	469·8
27·37	27·3	3	27·32	,,	,,	655·7
19·05	19·00	8s	19 00	,,	10·7	767·2
06·73		1		,,	,,	934·2
2692·43	2692·3	3	2692·35	0·77	,,	37132·1
82·98	82·8	5	82·86	,,	10·8	275·1
70·81	70·7	5n	70·73	,,	10·9	430·9
69·79	69·6	5n		,,	,,	445·2
63·31		1s		,,	,,	536·4
57·03	56·8	1b		,,	,,	625·1
52·73	52·70	7	52·70	0·76	11·0	686·2
	32·6	1n		,,	,,	974·3
17·46	17·5	3n		,,	11·1	38193·3
14·78	14·8	1s	14·74	,,	,,	233·1
14·33		2		,,	,,	238·6
12·43	12·4	5	12·40	,,	,,	267·5
2598·24	2598·15	9r	2598·16	0·75	11·2	477·1
90·42	90·4	5b		,,	,,	592·6

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ANTIMONY (ULTRA-VIOLET SPARK SPECTRUM)—*continued*.

Wave-length		Intensity and Character	Previous Observations Kayser and Runge (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
Eder and Valenta	Exner and Haschek			λ+	$\frac{1}{\lambda}$−	
	2586·8	1n		0·75	11·3	38646·5
2574·24	74·1	3s	74·14	,,	,,	832·8
71·64	71·6	1n		,,	,,	874·4
	70·6	1n		,,	,,	890·1
67·87	67·8	1s		,,	11·4	931·4
65·62	65·6	3b		,,	,,	965·5
	57·6	1b		0·74	,,	39087·8
54·81	54·8	1s	54·72	,,	,,	130·4
44·10	43·9	3n		,,	11·5	310·6
28·68	28·62	9r	28·60	,,	11·6	535·2
28·58		1		,,	,,	536·3
	22·9	1		,,	,,	625·3
20·30	20·3	1n		,,	,,	666·2
	14·5	1n	14·64	0·73	,,	757·7
10·66	10·6	1	10·60	,,	11·7	818·8
	07·8	1n		,,	,,	863·9
	2488·3	1		,,	11·8	40176·3
	83·3	1		,,	,,	257·2
	81·8	1	2481·81	,,	,,	281·5
2480·55	80·5	2	80·50	,,	,,	301·8
78·45	78·4	4		,,	,,	336·0
74·80	74·6	1	74·63	,,	11·9	395·4
45·66	45·7	5	45·59	0·72	12·0	876·7
29·55		1		,,	,,	41147·7
26·52	26·5	2s	26·44	,,	12·2	199·1
22·31	22·2	2s	22·21	,,	,,	270·7
2395·35	2395·4	1n	2395·31	0·71	12·4	735·2
83·77	83·8	2n	83·71	,,	,,	938·0
73·84		3 Fe	73·78	0·70	12·5	42113·3
	61·2	1n		,,	,,	337·7
60·58	60·6	1	60·60	,,	,,	349·9
16·02		3		0·69	12·9	43164·8
11·71	11·8	4	11·60	,,	13·0	245·0
11·47				,,	,,	249·5
06·56	06·6	2n	06·56	,,	,,	341·6
2295·99		1		,,	13·1	526·9
93·48	93·5	2s	2293·54	,,	,,	588·8
88·99	89·1	1	89·09	,,	,,	674·3
62·51		3	62·55	0·68	13·4	44185·3
46·97		1		,,	13·5	490·9
24·92		3	25·06	0·67	13·7	931·7
22·02		1	22·10	,,	,,	990·4
20·70		3	20·85	,,	,,	45017·1
08·48		4	08·65	,,	13·8	266·2
03·59		2	03·83	,,	13·9	366·6
01·36		1	01·46	,,	,,	412·6
2179·23		4	2178·33	0·66	14·1	873·9
75·90		4	75·99	,,	,,	943·9
70·13		3		,,	14·2	46066·1
44·99		4	45·10	,,	14·4	605·9
41·76		1	41·76	,,	,,	676·2
39·75		3	39·89	,,	,,	720·0
18·57		1		0·65	14·6	47187·1
2098·47		1	2098·47	,,	14·8	639·0

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Arsenic (Spark Spectrum).

Exner and Haschek, 'Sitzungsber. kais. Akad. Wissensch. Wien,' cx. 1901.

Wave-length	Intensity and Character	Previous Observations Kayser and Runge (Arc)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4540·0	2b		1·24	6·1	22020·3
4495·5	2b		1·23	„	238·4
66·6	1b		„	6·2	382·2
4368·50	1n		1·20	„	885·0
4229·5	1b		1·16	6·6	23636·8
08·1	1b		„	„	757·1
4197·8	1b		1·15	6·7	815·3
88·80	2		„	„	871·0
4082·8	1b		1·12	6·9	24486·1
64·55	1n		„	„	596·1
37·18	30		1·11	7·0	762·8
3948·85	1b		1·09	7·2	25316·6
31·4	1b		1·08	„	429·0
22·60	100		„	„	486·3
3545·75	1n		0·99	8·0	28194·8
3256·0	2n		0·91	8·7	30703·8
3119·70	1n	3119·69	0·88	9·1	32045·3
16·7	2b		„	„	076·1
3032·97	1	3032·96	0·86	9·4	961·6
2991·2	1n	2991·11	„	9·6	33415·1
59·8	3b		0·84	9·7	478·4
26·3	1b		„	9·8	34158·4
2898·86	2	2898·83	0·81	9·9	486·4
60·60	8	60·54	„	10·1	947·6
43·80	2n		„	10·2	35154·0
31·0	1b		„	„	313·0
2780·37	10	2780·30	0·79	10·4	956·0
45·10	5	45·09	„	10·6	36417·9
2493·07	4	2492·98	0·73	11·8	40099·4
56·62	4	56·61	0·72	12·0	694·3
37·30	1	37·30	„	12·1	41016·9
2381·32	2n	2381·28	0·71	12·5	978·0
70·87	3	70·85	0·70	„	42166·1
69·75	3	69·75	„	„	186·0
63·10	1n	63·12	„	12·6	304·6
50·02	10	49·92	„	12·7	558·3
2288·23	3n	2288·19	0·69	13·2	43688·7
71·53	1n	71·46	1·68	13·3	44009·9
66·82	1n	66·79	„	„	101·4
29·96	1		0·67	13·6	830·2
2192·21	2n		„	13·9	45602·2
65·53	2n	2165·64	0·66	14·2	46163·9
56·3	1n		„	14·3	361·4
34·37	1		„	14·5	837·7

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Absorption Spectra and Chemical Constitution of Organic Substances.—*Fifth Interim Report of the Committee, consisting of* Professor W. NOEL HARTLEY (*Chairman and Secretary*), Professor F. R. JAPP, Professor J. J. DOBBIE, *and* Mr. ALEXANDER LAUDER, *appointed to investigate the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.*

THE work of two of the members of the Committee, Dr. Dobbie and Mr. Lauder, has been exclusively devoted to the investigation of certain alkaloids, and the connection between their chemical constitution and their absorption spectra, and the results they have obtained since the last meeting at Belfast constitute the substance of this report.[1]

NOTE.—As sometimes the nitrates of the alkaloids are well-crystallised salts, the examination has been in certain cases made with nitrates. It is necessary to observe, however, that unlike chlorides, sulphates, and acetates, which are very diactinic and exert only a general absorption, nitric acid and the nitrates give characteristic absorption bands.[2] This does not affect the spectra here referred to, but it might happen that if the effect of the nitric acid were not taken into account, erroneous conclusions could be drawn from the absorption band of the nitric acid being attributed to the organic base.

In a paper communicated to the Royal Society eighteen years ago by Hartley,[3] it was proved that the principal alkaloids give highly characteristic absorption spectra which can be used for their identification and for ascertaining their purity. Furthermore, that alkaloids closely related to one another, like quinine and quinidine, cinchonine and cinchonidine, all contained a similar nucleus, which was probably formed by the conjugation of four pyridine or two quinoline groups, and that the opium alkaloids had also a characteristically constituted nucleus which is either a benzene or a pyridine derivative. The effect of alkyl and acetyl substitutions on the curve of absorption was demonstrated, the increased intensity of absorption of the apo-derivatives was shown and accounted for, and the occurrence of several oxidised radicals—hydroxyl, methoxyl, carbonyl, or carboxyl—in the constitution of an alkaloid was shown to be capable of causing remarkable differences in the absorption curves of the original nucleus. At the time at which this paper was published, however, little progress had been made with the investigation of the alkaloids, and it was not possible, therefore, to trace any closer connection between their structure and their spectra. In this connection, however, the relationship of the absorption curves to the differences in constitution of quinoline, dihydroquinoline, and tetrahydroquinoline, was determined by Hartley.

The Absorption Spectra of Corydaline, Berberine, and the Opium Alkaloids.

The constitution of the principal members of the group of alkaloids to which corydaline and berberine belong—namely, papaverine, hydrastine,

[1] Dobbie and Lauder, *Chem. Soc. Trans.*, 1903, **83**, pp. 605, 626.
[2] Hartley, *Chem. Soc. Trans.*, 1902, **81**, and 1903, **83**.
[3] *Phil. Trans.*, 1885, Part II., p. 471.

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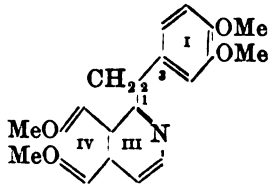
narcotine, and narceine—has now been definitely determined, and the examination of this group furnishes a good basis for the study of the relationship between the absorption spectra and the constitution of the alkaloids.

Since papaverine is, in some respects, more simply constituted than the other members of the group, it will be convenient to consider each of the others with reference to it. According to Goldschmiedt, the structure of papaverine is represented by the following formula :

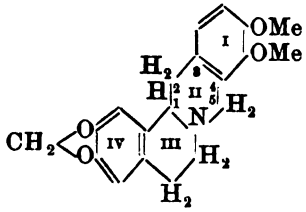
Papaverine.



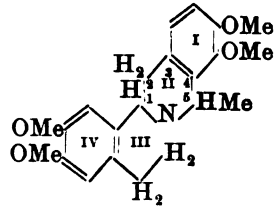
The absorption curve of papaverine shows two absorption bands, the first lying between $^1/\lambda$ 2998 (λ=3335) and $^1/\lambda$ 3295 (λ=3035), and the second between $^1/\lambda$ 3956 (λ=2528) and $^1\lambda$ 4555 (λ=2195).

Hydrastine differs structurally from papaverine in the following particulars : (i) The *iso*quinoline nucleus is partially reduced ; (ii) The two methoxyl radicals of the *iso*quinoline nucleus are replaced by a dioxymethylene group ; (iii) A methyl group is attached to the nitrogen atom ; (iv) A carbonyl group is attached to the carbon atom (4), and through the medium of an oxygen atom is also linked to carbon atom (2), which has only one atom of hydrogen attached to it. From this comparison, it is obvious that the two substances differ considerably in their constitution. On comparing the curve of the absorption spectra of hydrastine (fig. 4) with that of papaverine (fig. 2), it will be seen that there is a correspondingly wide difference between them ; hydrastine exhibits slightly less general absorption than papaverine, and shows only one absorption band which is wider and much more persistent than either of the absorption bands of papaverine. Narcotine only differs from hydrastine in containing an additional methoxyl group attached to ring IV, and the two alkaloids give practically identical absorption spectra (figs. 4 and 5). Assuming the constitution of corydaline, as determined by Dobbie and Lauder, to be correct, it is represented by the second of the following formulæ :

Tetrahydroberberine.



Corydaline.



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On comparing this formula with that of papaverine, the differences will be seen to consist in the partial reduction of the *iso*quinoline nucleus and in the presence of carbon atom (5), which, with its associated methyl group, is linked on the one hand to carbon atom (4), and on the other to the nitrogen atom, thus forming a fourth closed chain in the molecule. Here, again, the difference between the absorption spectra and those of papaverine is very marked. The amount of general absorption is less, and there is only one absorption band, which is, however, better defined and more persistent than the papaverine bands (figs. 2 and 6).

In discussing the relations between corydaline and berberine, it is to be remembered that corydaline corresponds to tetrahydroberberine, and berberine to dehydrocorydaline. The constitutional connection between corydaline and tetrahydroberberine is undoubtedly very close,[1] as a comparison of the above formulæ will show, and between the spectra of the two substances there is also a very close relation (figs. 6 and 7), the only difference being that the general absorption of tetrahydroberberine is slightly greater than that of corydaline.

When papaverine is reduced to tetrahydropapaverine, it is brought structurally very near to corydaline. A comparison of the formulæ of the two substances shows that the former substance differs from the latter in the absence of carbon atom (5) of ring II with its associated hydrogen atom and methyl group. The spectra of the two compounds are almost identical (figs. 3 and 6). Viewing corydaline as derived from tetrahydropapaverine by the addition of CH_2 forming a fourth closed chain in the molecule, it might have been anticipated that the difference between the absorption spectra of the two substances would be greater than is found to be the case. It should be noted, however, that ring II in corydaline is a reduced ring, and would not therefore exert the same influence on the absorption spectra as the formation of a pyridine ring. It might be expected to produce an effect comparable with that produced by the substitution of a dioxymethylene for two methoxyl groups, which, we shall show later, is slight in compounds of high molecular weight.[2]

Narceine is the extreme member of this group. It has two benzene nuclei, but no pyridine ring, and in other particulars differs considerably in constitution from papaverine. The absence of any absorption band differentiates the spectra widely from those of the other members of the group (fig. 22).

Note.—This was accounted for by Hartley in the following explanation: 'Carbonyl, carboxyl, hydroxyl, and methoxyl on side-chains, or as forming a portion of the substituted benzene nuclei, exhibit great absorptive power, and the occurrence of several oxidised radicals may cause the following variations in spectra: (*a*) the absorption band becomes so widened as to extend into the region of rays affected by naphthalene, quinoline, and their derivatives; (*b*) or the absorption is so powerful that it extends to rays less refrangible than those in which the band is situated, and continues so far down the curve that the selective absorption is not made manifest. Narceine appears to be a good example of this; its absorptive power is very great, extending into the

[1] *Chem. Soc. Trans.*, 1902, **81**, 145.

[2] Hartley, *Chem. Soc. Trans.*, 1885, **47**, 691; Hartley and Dobbie, *Chem. Soc. Trans.* 1900, **77**, 846.

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region of such low refrangibility as λ 3000 when 1 mm. of liquid is examined containing only $\frac{1}{1000}$th of substance, so that no band is visible. The remarks on narceine are also applicable to papaverine in every particular.'[1]

Dobbie and Lauder[2] have shown that corydaline and berberine give rise to parallel series of derivatives. The absorption spectra of the corresponding derivatives are related to one another in the same way as the spectra of the parent substances. When corydaline is acted on with mild oxidising agents, four atoms of hydrogen are removed, and a yellow substance is obtained, which stands in the same relation to corydaline as berberine to tetrahydroberberine.[3]

Oxidation with dilute nitric acid converts corydaline and berberine respectively into the dibasic corydic and berberidic acids:

$$C_{13}H_6(CH_3)(OCH_3)_2\cdot N(CO_2H)_2,$$
Corydic acid.

$$C_{13}H_7(CH_2O_2)\cdot N(CO_2H)_2,$$
Berberidic acid.

whilst oxidation with permanganate gives rise, amongst other products, to corydaldine in the former case, and to ω-aminoethylpiperonylcarboxylic anhydride in the latter. The corresponding derivatives differ structurally from one another in the same way as corydaline and tetrahydroberberine, excepting that, in the case of corydaldine and ω-aminoethylpiperonylcarboxylic anhydride, ring II having disappeared, the difference between the two compounds is confined to the replacement of the two methoxyl groups of the former by dioxymethylene in the latter. The spectra of the corresponding derivatives (figs. 10 and 11, and 14 and 15), exhibit the same close relationship as those of the alkaloids themselves. The general absorption of the berberine derivatives is, however, always slightly greater than that of the corresponding corydaline derivatives. This is probably due to the influence of the dioxymethylene group, and the correctness of this inference is supported by the fact that piperonylic acid, $C_6H_3(CH_2O_2)\cdot CO_2H$, shows slightly greater general absorption than veratric acid, $C_6H_3(OCH_3)_2\cdot CO_2H$ (figs. 12 and 13).

Whilst the spectra of corydaldine and ω-aminoethylpiperonylcarboxylic anhydride approach one another closely, they differ widely from those of cotarnine and hydrastinine (figs. 14, 15, and 16), the corresponding oxidation products of narcotine and hydrastine respectively. The difference finds a sufficient explanation in the fact that whilst all four substances are nearly related, the chain containing the nitrogen atom, which is closed in the two former, is open in the two latter. When, however, hydrastinine is oxidised by means of an aqueous solution of potassium hydroxide, the open chain is closed, and oxyhydrastinine results, the absorption spectra of which substance are almost identical with those of corydaldine and ω-aminoethylpiperonylcarboxylic

[1] *Phil. Trans.*, 1885. [2] *Chem. Soc. Trans.*, 1902, 81, 145.
[3] *Ibid.*, 1902, 81, 145.

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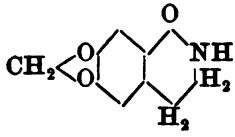
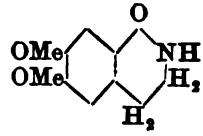
anhydride (figs. 14, 15, and 17). The relationship between these compounds is shown by the following formulæ :—

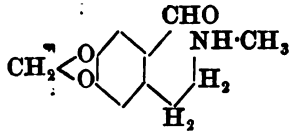
ω-Aminoethylpiperonylcarboxylic anhydride.



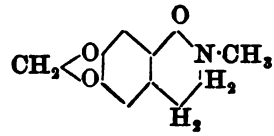
Corydaldine.



Hydrastinine.



Oxyhydrastinine.



Though Dobbie and Lauder have found that cotarnine and hydrastinine in alcoholic solution do not possess the constitution commonly assigned to them, this in no way affects the argument, since there is an important constitutional difference between oxycotarnine and oxyhydrastinine on the one hand, and cotarnine and hydrastinine on the other, whatever formulæ be accepted for the two latter.

Again, when the pyridine ring of cotarnine and hydrastinine is closed by the conversion of these substances into their salts or by their reduction to hydro-derivatives, the changes of structure are reproduced in a striking manner in the spectra.

Relationships established between differences in Constitution and Absorption Spectra, which may be applied to the study of Alkaloids of unknown Constitution.

It is now known that many alkaloids which possess the same formula are stereoisomerides. Alkaloids which are related in this way give, like other stereoisomerides, identical spectra.[1] Illustrations of this are afforded by *d*-corydaline and *i*-corydaline (fig. 16), narcotine and gnoscopine (fig. 15), tetrahydroberberine and canadine (fig. 17). Quinidine (conquinine) and cinchonidine also give absorption spectra identical with those of quinine and cinchonine respectively, of which substances they are probably stereoisomeric forms (figs. 18 and 19). This relationship might sometimes be used to assist the investigation of cases of suspected stereoisomerism. Where, for example, two compounds of the same formula are known, one active and the other inactive, it may be inferred that they are not optical isomerides if they have different absorption spectra.

A case in point is afforded by canadine and papaverine, which possess the same molecular formulæ but give widely different absorption spectra. Even if it were not known otherwise that these two substances

[1] Hartley and Dobbie, *Chem. Soc. Trans.*, 1900, 77, 498 and 509.

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are structurally different, this might be inferred from the differences in their absorption spectra (figs. 2 and 7). Canadine has long been regarded as a stereoisomeride of tetrahydroberberine. This question might have been decided by a comparison of the spectra of the two substances, which had been already undertaken when Gadamer[1] published an account of the resolution of tetrahydroberberine into its active components, and showed that one of them was identical with canadine. The result of the spectroscopic examination points to the same conclusion (fig. 7).

According to Gadamer,[2] inactive corydaline exists in two modifications, one melting at 134–135°, and the other at 158–159°. The latter of these only can be resolved into dextro and inactive corydalines. The inactive modification of lower melting-point which cannot be resolved, might either be a structural or a stereoisomeric modification of corydaline. The fact that its spectra are identical with those of natural corydaline (fig. 6) affords strong presumption in favour of the view that the two are structurally identical.

Homologous alkaloids give practically identical spectra. It has been shown from the examination of many homologous substances that the replacement of an atom of hydrogen by a methyl group produces very little effect on the spectra, even when the compounds are of low molecular weight.[3] The effect is still less noticeable when the replacement occurs in substances of high molecular weight, such as some of the alkaloids. The effect is such that in every case it may have been predicted.

Codeine and morphine (fig. 1) were examined by Hartley,[4] and his curves show clearly the relation between these two compounds. We have examined numerous other cases of homologous alkaloids, and find that they all give practically identical spectra. The curves of corybulbine, $C_{21}H_{25}O_4N$ (fig. 20), and corydaline, $C_{23}H_{27}O_4N$ (fig. 6), and those of quinine, $C_{20}H_{24}O_2N_2$, and cupreine, $C_{19}H_{22}O_2N_2$ (fig. 18), may be referred to as examples. When, therefore, the formulæ of two alkaloids differ by CH_2, it may be inferred with certainty, if they give dissimilar spectra, that they are not homologous. On the other hand, it cannot be inferred with certainty that two substances which differ by CH_2, and have very similar spectra, are really homologous, because the difference in the formulæ may be due to other slight structural differences.

The formula of bulbocapnine, $C_{19}H_{19}O_4N$, differs from that of papaverine, $C_{20}H_{21}O_4N$, and of tetrahydroberberine, $C_{20}H_{21}O_4N$, by CH_2, but the wide difference between the spectra of all three substances (figs. 21, 2, and 7) renders it highly improbable that bulbocapnine is homologously related to either of the others. What is known of the chemistry of bulbocapnine entirely bears out this conclusion.[5]

Many minor modifications of structure in alkaloids are unaccompanied by any marked difference in the spectra, even where the same

[1] *Arch. Pharm.*, 1901, **239**, 648.
[2] *Ibid.*, 1902, **240**, 19.
[3] Hartley and Huntington, *Phil. Trans.*, 1879, Part I., 257.
[4] *Phil. Trans.*, 1885, Part II., 471.
[5] Gadamer and Ziegenbein, *Arch. Pharm.*, 1902, **240**, 81.

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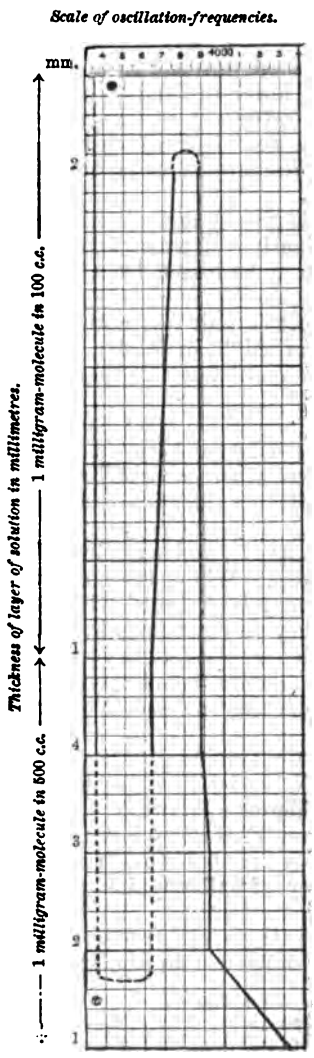
FIG. 1.—Morphine,
$C_{17}H_{19}O_3N + H_2O$.
(*In alcoholic solution*).

The curve of codeine is identical with this (*see also Hartley*, loc. cit.).



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modifications would produce an appreciable effect on the spectra of compounds of low molecular weight. Corydaline, tetrahydroberberine, and their derivatives afford instances in which the replacement of $2(OCH_3)$ by CH_2O_2 does not markedly alter the spectra, and narcotine and hydrastine furnish an example in which the introduction of an additional methoxyl group is unaccompanied by any considerable effect.

The case of cinchotenine and cinchonine may be quoted as another instance. In cinchotenine the side chain $\cdot CH : CH_2$ of cinchonine is oxidised to a carboxyl group without the spectra being appreciably affected. The resemblance between the two series of spectra is so close that it would at once suggest a near structural relation of the substances, even if we knew nothing of their chemistry.

The reduction of closed chain compounds is accompanied by a complete change in the character of the spectra.[1] Good illustrations of this are afforded by the widely different spectra of berberine (fig. 9) and tetrahydroberberine (fig. 7), dehydrocorydaline (fig. 8) and corydaline (fig. 6), papaverine and tetrahydropapaverine (figs. 2 and 3). There are, however, cases in which partial reduction produces very little change. Hydroquinine, $C_{20}H_{26}O_2N_2$, is unquestionably very closely related to quinine, $C_{20}H_{24}O_2N_2$, from which its formula only differs in containing two more atoms of hydrogen. The difference between the spectra of the two substances is hardly perceptible, and it is highly probable, therefore, that the addition of the two atoms of hydrogen is unaccompanied by any important change of structure. The change probably consists in the reduction of the side chain.

From the results of the examination of more than thirty alkaloids, it may be laid down as a general rule that those which agree closely in structure give similar absorption curves, whilst those which differ in essential points of structure give dissimilar curves.

This principle has already been recognised and applied in previous investigations, particularly in the study of coloured substances and dyes, and it is probably capable of extended application in the case of the alkaloids, as most of these compounds have a high molecular weight, and changes may be effected in their molecules without alteration of the spectra which, in substances of lower molecular weight, would be attended by wide differences. The essential identity of constitution subsisting between two alkaloids can often be detected by the spectroscope in spite of differences of structure. Cinchonine and cinchotenine give practically identical curves, whereas styrolene and benzoic acid, which differ in the same way, give very different curves. If, therefore, an alkaloid of unknown constitution is found to give spectra closely resembling those of an alkaloid of known constitution, it may with great probability be inferred that the two only differ in the details of their structure.

The systematic study of absorption spectra is of real practical value in the investigation of the alkaloids, and may often be the means of saving much time and labour in their chemical investigation, especially in dealing with a large number of closely related compounds.

[1] Hartley, *Chem. Soc. Trans.*, 1885, 47, 691, and *Phil. Trans.*, 1885; also Hartley and Dobbie, *Chem. Soc. Trans.*, 1900, 77, 846.

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Experimental Details.

For the specimens of the opium alkaloids, including gnoscopine, we are indebted to the kindness of Messrs. T. and H. Smith, of Edinburgh, and for the specimens of oxyhydrastinine and ω-aminoethylpiperonylcarboxylic anhydride, to Professor W. H. Perkin, jun. The specimens of inactive and artificial corydaline, corybulbine, tetrahydroberberine, tetrahydropapaverine, dehydrocorydaline, corydic and berberidic acids, corydaldine, and hydrastinine were prepared in the laboratory of the University College of North Wales, Bangor; and our best thanks are due to Messrs. C. K. Tinkler, K. S. Caldwell, and Ed. Jones for assisting in the preparation of some of these substances, and to Mr. C. P. Finn for assisting in photographing the spectra. The remaining alkaloids were obtained by purchase. In every case the specimens were tested as to their purity, and, where necessary, subjected to purification. Whenever possible, specimens were obtained from at least two distinct sources, and several independent examinations were made of each specimen.

In photographing the spectra and in representing them graphically, owing to the slight solubility of some of the substances examined, it was not always possible to get a solution of 1/100, and thicker layers of a more dilute solution had to be employed. In such cases, for convenience of reference, 25 mm. of a solution of 1/500 have been plotted as equivalent to 5 mm. of a solution of 1/100. Except in the case of hydrastine, all the curves are drawn to the same scale. The position of the transmitted portions of the spectra and of the absorption band have been marked on one of the curves (fig. 3).

We may remark that it is difficult by means of curves to give a proper representation of the photographs, it being found impracticable to adequately represent differences of intensity as well as extent of absorption upon which the similarity or difference between two series of spectra often to a large extent depends.

By far the most satisfactory comparison is that which is made by the actual inspection of the photographs. When reasonable care is taken to work under similar conditions, the results are remarkably constant. We have never discovered any discrepancy between the photographs of the same preparation, even when taken by different operators at wide intervals of time. Hartley having worked in 1882 and again in 1884 with constant weights and not with molecular quantities of the alkaloids, it was found necessary, for purposes of comparison, to repeat the examination of a few of the alkaloids which he had previously examined. In so far as it is possible in such cases to compare the results, they show remarkably close agreement.

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FIG. 2.—Papaverine, $C_{20}H_{21}O_4N$.
(*In alcoholic solution.*)

[*Cf.* Hartley, *Phil. Trans.*, 1885, Pt. II., 471.]

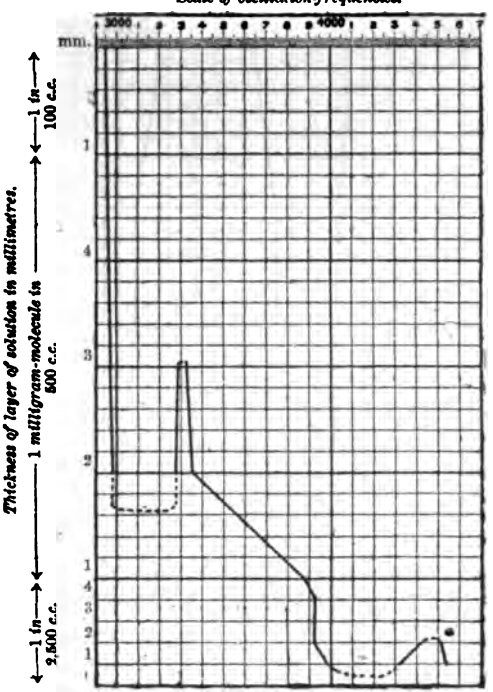
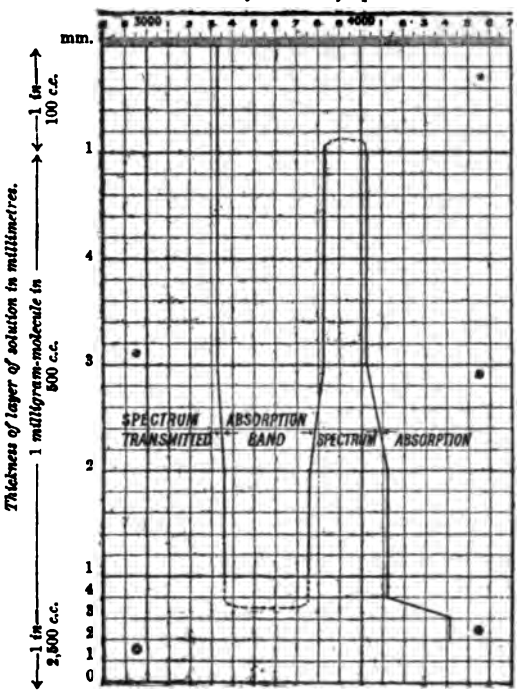

Scale of oscillation-frequencies.
3000
4000
mm.
Thickness of layer of solution in millimetres.
1 in ← 2,500 c.c. — 1 milligram-molecule in 500 c.c. → 1 in 100 c.c.

FIG. 3.—Tetrahydropapaverine, $C_{20}H_{23}O_4N$.
(*In alcoholic solution.*)



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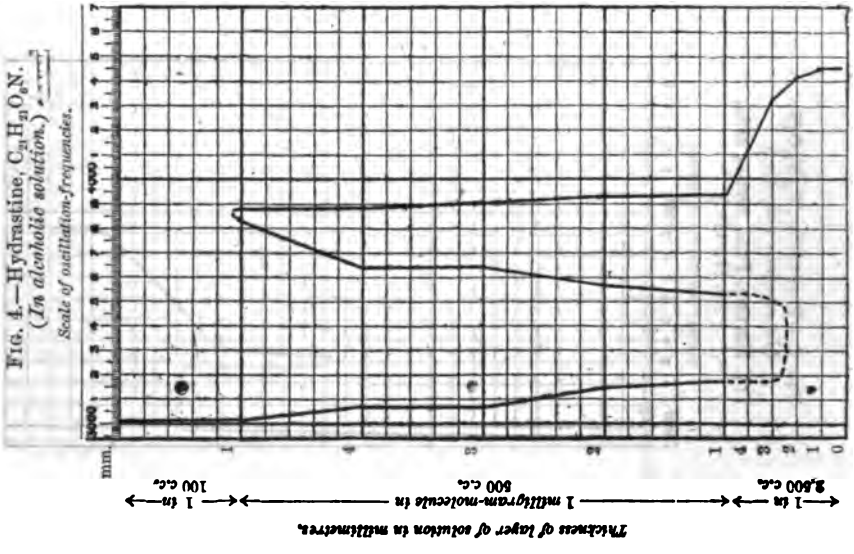

FIG. 4.—Hydrastine, $C_{21}H_{21}O_6N$.
(In alcoholic solution.)
Scale of oscillation-frequencies.

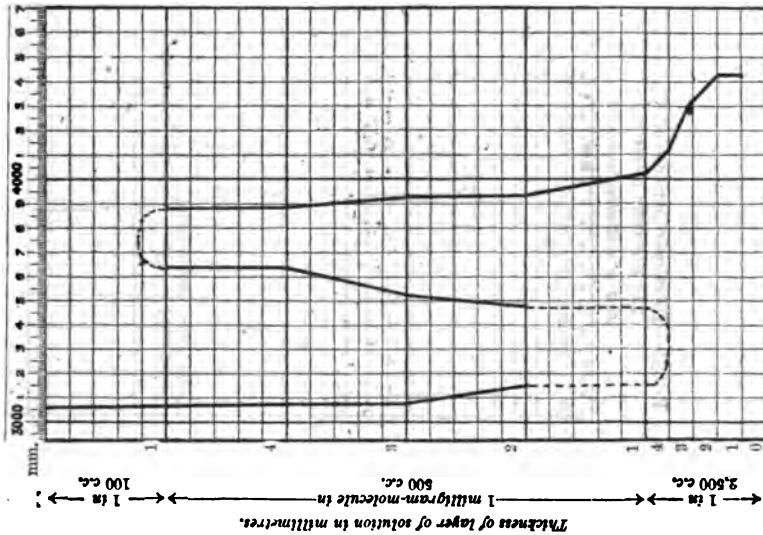

FIG. 5.—Narcotine, $C_{22}H_{23}O_7N$.
(In alcoholic solution.)
[*See also* Hartley, loc. cit.]
The curve of gnoscopine is identical with this.
Scale of oscillation-frequencies.

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FIG. 6.—Corydaline, $C_{22}H_{27}O_4N$.

The curves of artificial corydaline and of l*-corydaline are identical with this.*

(*In alcoholic solution.*)

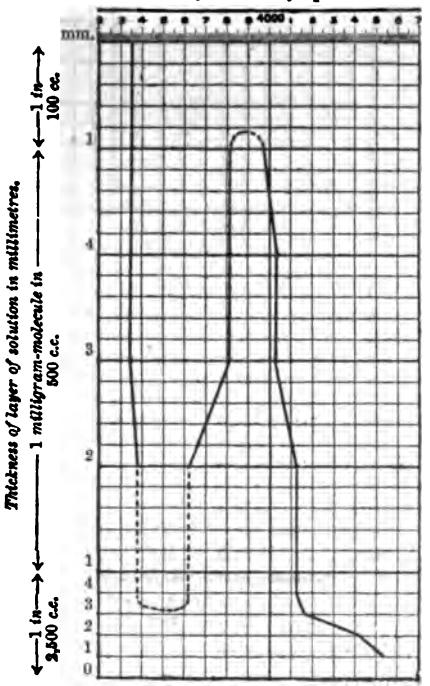
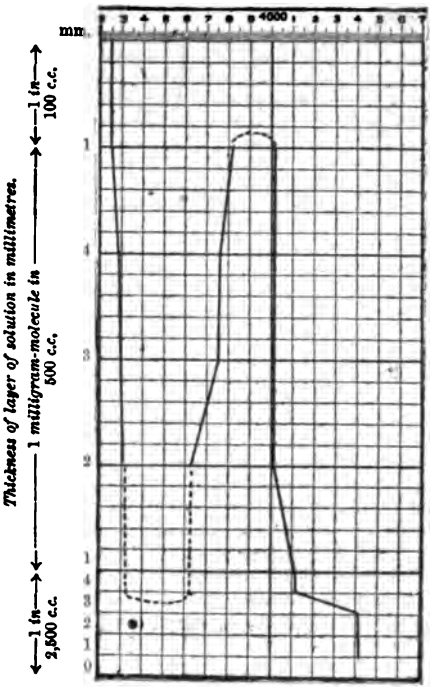


FIG. 7.—Tetrahydroberberine, $C_{20}H_{21}O_4N$.

(*In alcoholic solution.*)

The curve of canadine is identical with this.



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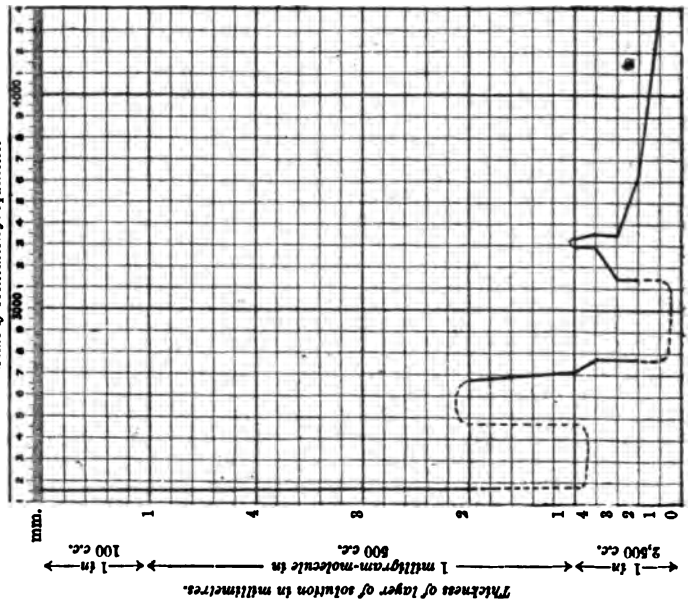
Thickness of layer of solution in millimetres.
1 in — 2,500 c.c.
1 milligram-molecule in 500 c.c.
1 in — 100 c.c.
mm.
Scale of oscillation-frequencies.

FIG. 9.—Berberine nitrate, $C_{20}H_{17}O_4N.HNO_3$.
(*In aqueous solution.*)

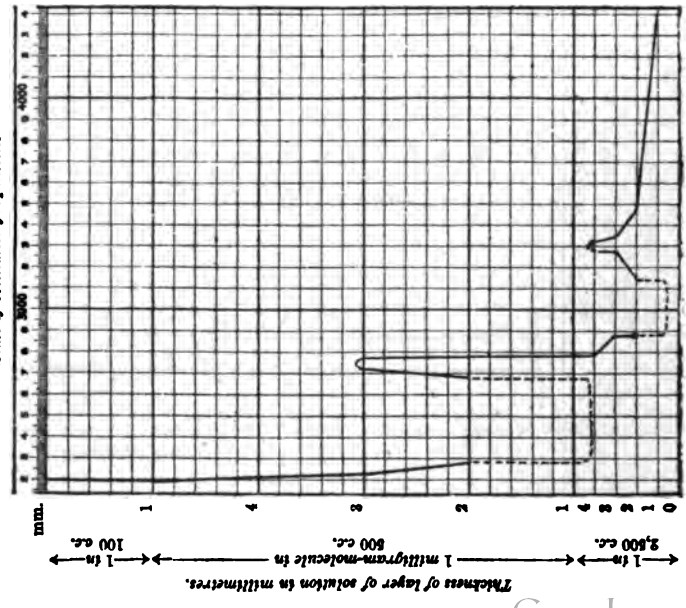
Thickness of layer of solution in millimetres.
1 in — 2,500 c.c.
1 milligram-molecule in 500 c.c.
1 in — 100 c.c.
mm.
Scale of oscillation-frequencies.

FIG. 8.—Dehydrocorydaline nitrate,
$C_{22}H_{23}O_4N.HNO_3 + 2H_2O$.
(*In aqueous solution.*)

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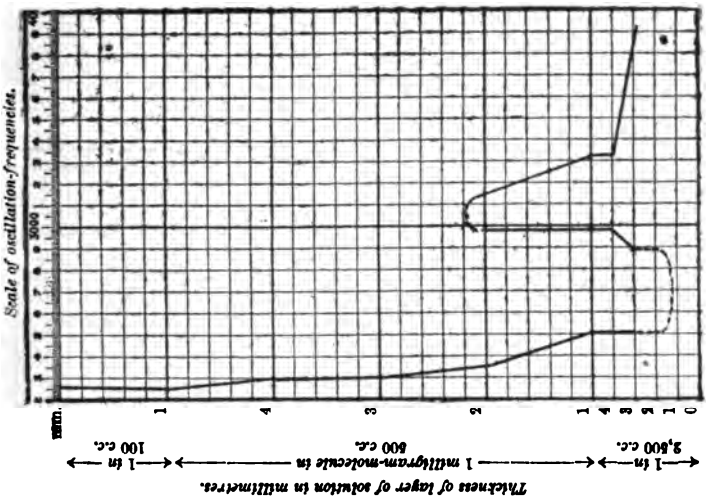
Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in 5,500 c.c.
1 milligram-molecule in 500 c.c.
1 in 100 c.c.

FIG. 11.—Berberidic acid, $C_{11}H_7N(CH_3O_2)(CO_2H)_2$. (*In aqueous solution.*)

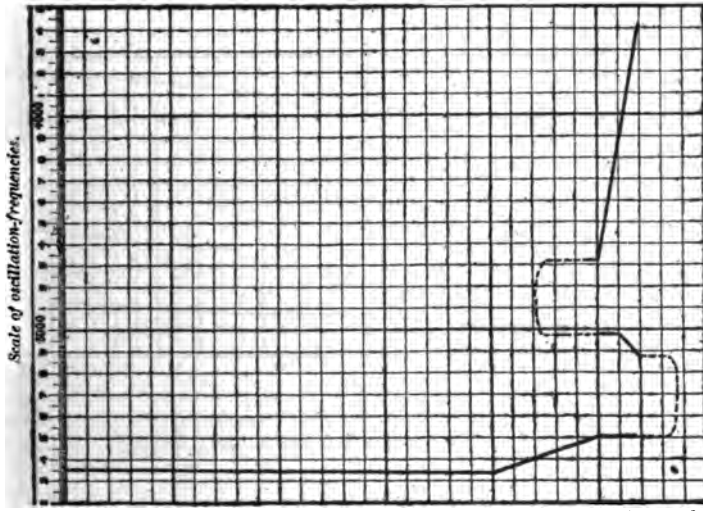
Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in 5,500 c.c.
1 milligram-molecule in 500 c.c.
1 in 100 c.c.

FIG. 10.—Corydic acid, $C_{14}H_9N(OCH_3)_2(CO_2H)_2 + \frac{1}{2}H_2O$. (*In aqueous solution.*)

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FIG. 13.—Piperonylic acid, $C_6H_3(CH_2O_2)CO_2H$.
(*In alcoholic solution.*)

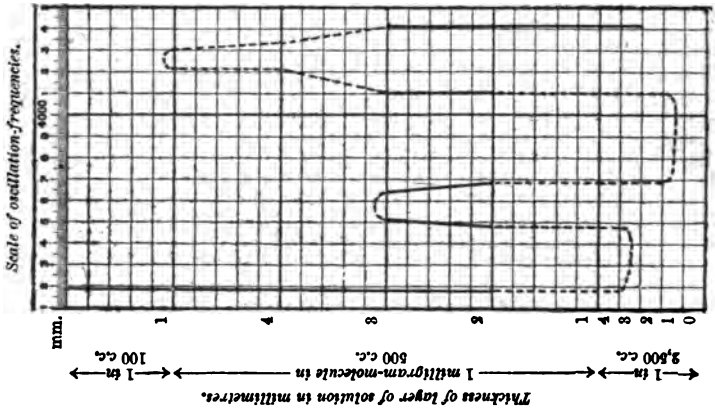
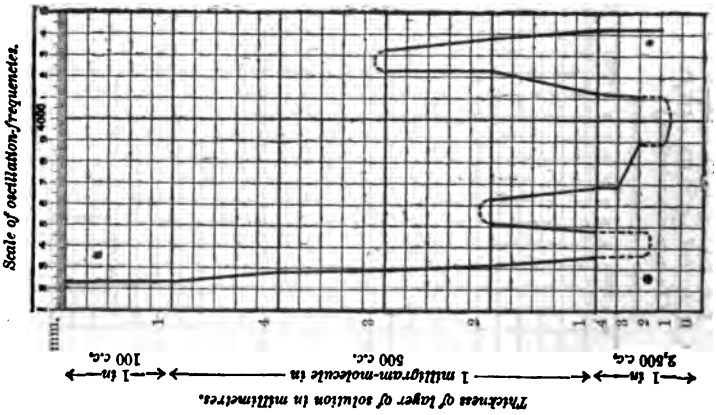


FIG. 12.—Veratric acid, $C_6H_3(OCH_3)_2CO_2H + 2H_2O$.
(*In alcoholic solution.*)



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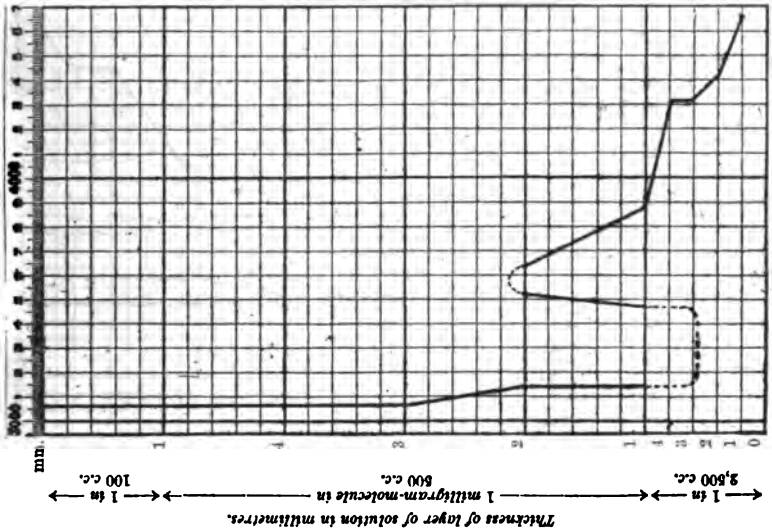
Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in 9,500 c.c.
1 milligram-molecule in 500 c.c.
1 in 100 c.c.

FIG. 13.—α-Aminoethylpiperonylcarboxylic anhydride, $C_8H_4O(CH_2O_2)$.
(In alcoholic solution.)

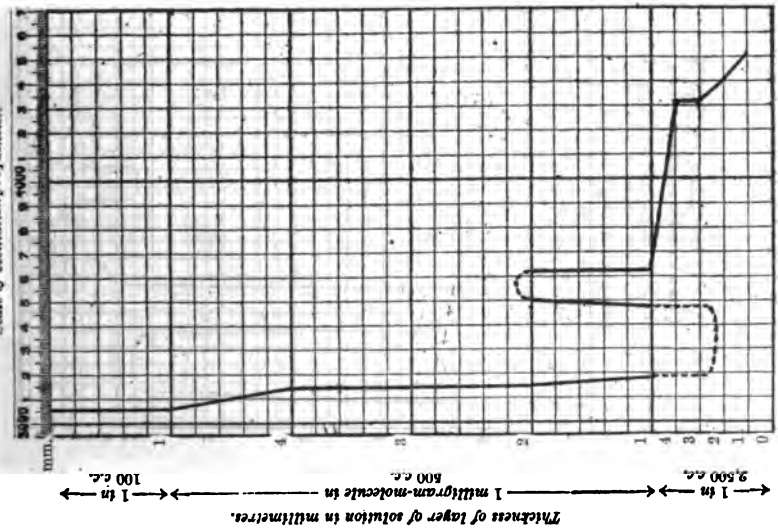
Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in 9,500 c.c.
1 milligram-molecule in 500 c.c.
1 in 100 c.c.

FIG. 14.—Corydaldine, $C_9H_4ON(OCH_3)_2$.
(In aqueous solution.)

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FIG. 16.—Hydrastinine, $C_{11}H_{13}O_2N$.
(In alcoholic solution.)

NOTE.—*The scale in this case is only one-fifth of the scale on which the other curves are drawn.*

Scale of oscillation-frequencies.

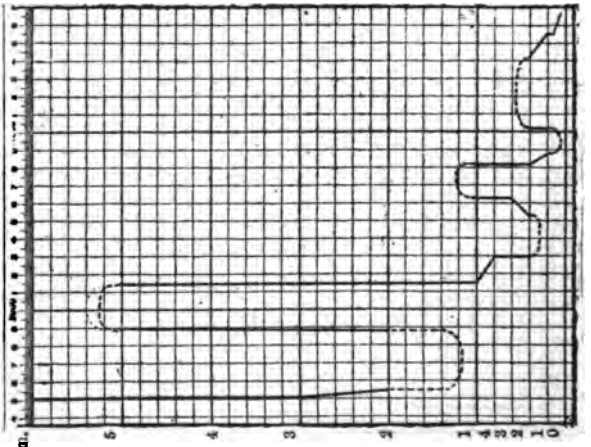
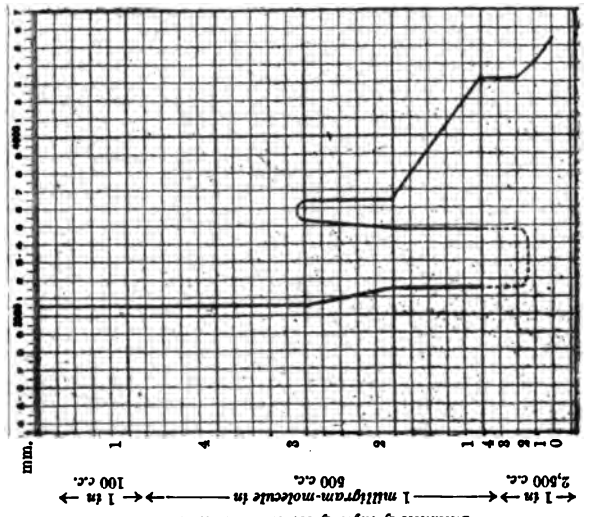


FIG. 17.—Oxyhydrastinine, $C_{10}H_9ON(CH_2O_2)$.
(In alcoholic solution.)

Scale of oscillation-frequencies.



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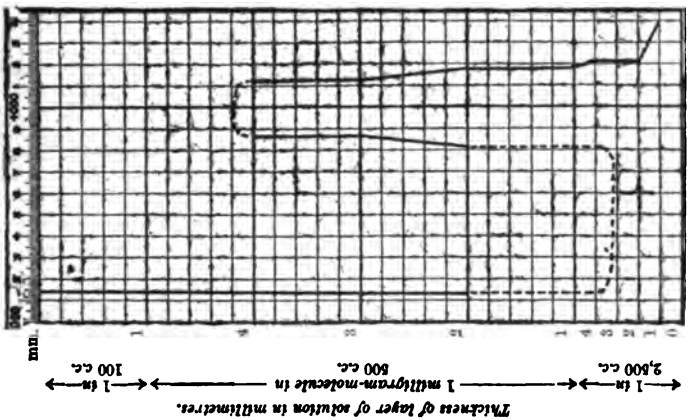

FIG. 19.—Cinchonine, $C_{19}H_{22}ON_2$.
(In alcoholic solution.)
[See also Hartley, loc. cit.*]*
The curve of cinchonidine is identical with this.

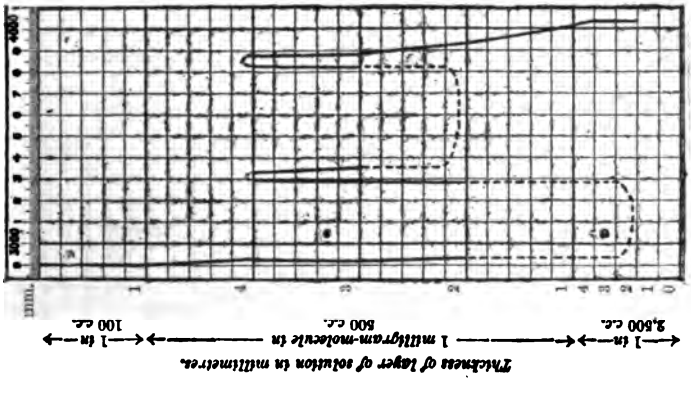

FIG. 18.—Quinine, $C_{20}H_{24}O_2N_2$.
(In alcoholic solution.)
[See also Hartley, loc. cit.*]*
The curves of quinidine and cupreine are identical with those of quinine.

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FIG. 20.—Corybulbine, $C_{21}H_{23}O_4N$.
(*In alcoholic solution.*)

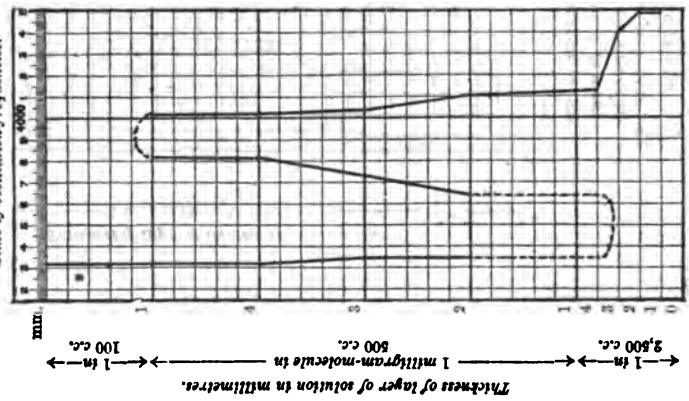

Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in — 2,500 c.c.
1 milligram-molecule in 500 c.c.
1 in — 100 c.c.

FIG. 21.—Bulbocapnine, $C_{19}H_{19}O_4N$.
(*In alcoholic solution.*)

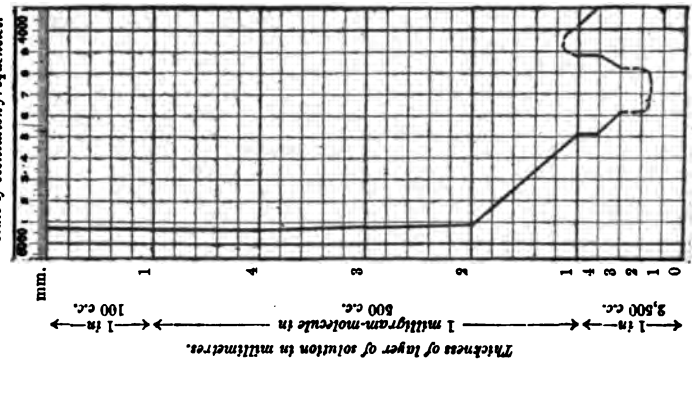
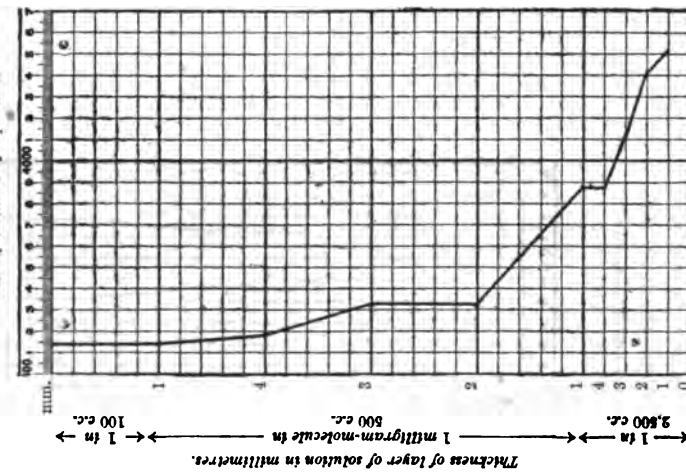

Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in — 2,500 c.c.
1 milligram-molecule in 500 c.c.
1 in — 100 c.c.

FIG. 22.—Narceine, $C_{23}H_{27}O_8N + 3H_2O$.
(*In alcoholic solution.*)


Scale of oscillation-frequencies.
mm.
Thickness of layer of solution in millimetres.
1 in — 2,500 c.c.
1 milligram-molecule in 500 c.c.
1 in — 100 c.c.

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PAPAVERINE.[1]

$C_{20}H_{21}NO_4$. M.P. 146°.

Solution in Alcohol.

(Fig. 2.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5, 4, and 3	Spectrum continuous to . . .	2938	3404
1 and 2	" " . . .	2982	3354
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum continuous to . . .	2982	3354
4	" " . . .	2998	3335
3	" " . . .	2998	3335
	Absorption band	2998 to 3295	3335 to 3035
	Spectrum continuous to . . .	3295 to 3328	3035 to 3005
2	" " . . .	2998	3335
	1*st Absorption band*	2998 to 3295	3335 to 3035
	Weak spectrum transmitted from 3295 to	3354	3035 to 2981
	1 *milligram-molecule in* 2,500 *c.c.*		
5, 4, 3	Spectrum continuous to . . .	3956	2528
2	" " . . .	3956	2528
	2nd Absorption band	3956 to 4555	2528 to 2195
1	Spectrum continuous to . . .	4038	2476
	2nd Absorption band	4038 to 4321	2476 to 2314
	Very weak spectrum from 4321 to .	4656	2148
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum continuous to . . .	4038	2476
	2nd Absorption band	4038 to 4321	2476 to 2314
	Very weak spectrum from 4321 to .	4656	2148
4	Spectrum continuous to . . .	4038	2476
	2nd Absorption band	4038 to 4321	2476 to 2314
	Weak spectrum from 4321 to . .	4656	2148
3	Same as 4, but with lines showing in the absorption band at . . .	4248	2354
2	Spectrum practically all transmitted, but very weak in position of absorption band.		
1	Spectrum practically all transmitted, but still very weak in position of absorption band.		

[1] *Cf.* Hartley, *Phil. Trans.*, 1885, Part II., 471.

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TETRAHYDROPAPAVERINE.

$C_{20}H_{23}NO_4$. M.P. 200°.

Solution in Alcohol.

(Fig. 3.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25 and 20	Spectrum continuous to . . .	3296	3033
15	" " . . .	3323	3009
10	" . . " . . .	3323	3009
	Line showing at	3886	2573
5	Spectrum continuous to . . .	3323	3009
	Absorption band	3323 to 3824	3009 to 2615
	Weak spectrum from 3824 to . .	4038	2476
4	Spectrum continuous to . . .	3323	3009
	Absorption band	3323 to 3824	3009 to 2615
	Spectrum transmitted from 3821 to .	4038	2476
3	Spectrum continuous to . . .	3323	3009
	Absorption band	3323 to 3824	3009 to 2615
	Lines showing at	3754, 3778, and 3792	2663, 2646, and 2637
	Spectrum transmitted from 3824 to .	4038	2476
2	Spectrum continuous to . . .	3354	2981
	Absorption band	3354 to 3754	2981 to 2663
	Weak spectrum from 3754 to . .	4113	2431
1	Same as 2 mm.		
	Lines in absorption band at . . .	3638 & 3694	2748 & 2707
	1 *milligram-molecule in* 2,500 *c.c.*		
5 and 4	Spectrum practically continuous to .	4113	2431
	Weak in position of absorption band.		
3 and 2	Spectrum continuous to . . .	4415	2265
	After this, practically all transmitted.		

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HYDRASTINE.

$C_{21}H_{21}NO_6$. M.P. 133°.

Solution in Alcohol.

(Fig. 4.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5, 4, and 3	Spectrum transmitted to . . .	2938	3403
2	„ „ . . .	2982	3353
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum transmitted to . . .	3046	3282
	Absorption band	3046 to 3324	3282 to 3615
	Lines faintly transmitted at . .	3824 & 3886	2615 & 2573
4	Spectrum transmitted to . . .	3076	3250
	Absorption band	3076 to 3638	3250 to 2748
	Spectrum feebly transmitted from 3638 to	3886	2573
3	Spectrum transmitted to . . .	3064	3263
	Absorption band	3064 to 3638	3263 to 2748
	Spectrum transmitted from 3638 to .	3903	2562
2	Spectrum transmitted to . . .	3148	3176
	Absorption band	3148 to 3568	3176 to 2802
	Spectrum transmitted from . . .	3568 to 3926	2802 to 2547
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum transmitted to . . .	3182	3142
	Absorption band	3182 to 3530	3142 to 2832
	Lines showing faintly in absorption band about	3295	3034
	Spectrum transmitted from 3530 to .	3926	2547
4	Spectrum transmitted to . . .	4119	2427
	Still weak in position of absorption band.		
3	Same as 4 mm., but faintly transmitted at	4321	2314
2	Spectrum transmitted to . . .	4406	2269
	Weak beyond	4119	2427
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum transmitted to . . .	4406	2269
	Line showing faintly at . . .	4531	2207
4	Same as 5 mm., with additional line at	4549	2198
2 and 1	Spectrum all transmitted.		

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Narcotine.[1]

$C_{22}H_{23}NO_7$. M.P. 173°.

Solution in Alcohol.

(Fig. 5.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25 and 20	Spectrum transmitted to . . .	2938	3404
15 and 10	„ „ . . .	2982	3353
5	„ „ . . .	3077	3249
	Absorption band	3077 to 3638	3249 to 2749
	Very weak spectrum from 3638 to .	3886	2573
4	Spectrum continuous to . . .	3077	3249
	Absorption band	3077 to 3638	3249 to 2749
3	Spectrum transmitted to . . .	3077	3249
	Absorption band	3077 to 3638	3249 to 2749
	Weak spectrum from 3638 to . .	3932	2543
2	Spectrum transmitted to . . .	3148	3177
	Absorption band	3148 to 3471	3177 to 2881
	Lines in absorption band about . .	3296 & 3323	3034 & 3009
1	Spectrum continuous to . . .	4038	2476
	Very weak in position of absorption band.		
	1 *milligram-molecule in* 2,500 *c.c.*		
5 and 4	Spectrum continuous to . . .	4127	2423
3	„ „ . . .	4127	2423
	Very faint to	4321	2314
2	Spectrum continuous to . . .	4420	2262
	Weak beyond	4127	2423
1	Spectrum continuous to . . .	4420	2262
	Faint to	4555	2195
	1 *milligram-molecule in* 12,500 *c.c.*		
5 to 1	Spectrum practically all transmitted.		

[1] Hartley, *Phil. Trans.*, 1885, Part II., p. 471.

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Corydaline.

$C_{22}H_{27}NO_4$. M.P, 135°.

Solution in Alcohol.

(Fig. 6.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5, 4, and 3	Spectrum transmitted to . . .	3323	3009
2	„ „ . . .	3323	3009
	Lines showing faintly at . . .	3886	2573
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3824	2981 to 2615
	Weak spectrum from 3824 to . .	3999	2500
4	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3824	2981 to 2615
	Weak spectrum	3824 to 4030	2615 to 2481
3	Same as 4 mm., but stronger.		
2	Spectrum transmitted to . .	3387	2952
	Absorption band	3387 to 3638	2952 to 2748
	Spectrum transmitted feebly from 3638 to	4107	2428
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	4123	2425
	Weak beyond.		
	Still weak in position of absorption band.		
4	Same as 5 mm., but somewhat stronger.		
3	Spectrum continuous to . . .	4166	2400
2	„ „ . . .	4406	2269
	Weak beyond	4123	2425
1	Spectrum continuous to . . .	4528	2208
	Weak beyond	4123	2425
	1 *milligram-molecule in* 12,500 *c.c.*		
	Spectrum practically al transmitted.		

Artificial Corydaline and Inactive Corydaline.

The spectra of artificial corydaline and inactive corydaline are identical with those of corydaline.

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Tetrahydroberberine.

$C_{20}H_{21}NO_4$. M.P. 167°.

Solution in Alcohol.

(Fig. 7.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c c.*		
25, 20, and 15	Spectrum continuous to . . .	3200	3125
10	„ „ . . .	3200	3125
	Line at	3886	2573
5	Spectrum continuous to . . .	3246	3080
	Absorption band	3246 to 3324	3080 to 3015
	Weak spectrum from 3824 to . .	4008	2495
4	Spectrum continuous to . . .	3296	3034
	Absorption band	3296 to 3754	3034 to 2664
	Weak spectrum from 3754 to . .	4038	2476
3	Spectrum continuous to . . .	3296	3034
	Absorption band	3296 to 3754	3034 to 2664
	Spectrum continuous from 3754 to .	4038	2664 to 2476
2	Spectrum continuous to . . .	3323	3009
	Absorption band	3323 to 3638	3009 to 2749
	Spectrum continuous from 3638 to .	4038	2476
1	Spectrum continuous to . . .	4132	2420
	Very weak in position of absorption band.		
	1 *milligram-molecule in* 2,500 *c.c.*		
5 and 4	Spectrum continuous to . . .	4132	2420
	Weak in position of absorption band.		
3	Spectrum continuous to . . .	4412	2266
	Weak in position of absorption band.		
	Very weak beyond	4132	2420
2 and 1	Spectrum continuous to . . .	4412	2266
	Very weak beyond.		

Canadine.

The spectra of canadine are identical with those of tetrahydroberberine.

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Dehydrocorydaline Nitrate.

$C_{22}H_{22}NO_4HNO_3 + 2H_2O$.

Aqueous Solution.

(Fig. 8.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 milligram-molecule in 100 c.c.		
5, 4, 3	Spectrum practically all absorbed.		
2	Spectrum feebly transmitted to . .	2162	4625
	1 milligram-molecule in 500 c.c.		
5 and 4	Spectrum transmitted to . . .	2202	4541
3	" " . . .	2244	4456
	1st Absorption band	2244 to 2714	4456 to 3684
	Spectrum very feebly transmitted from 2714 to	2768	3612
	Spectrum transmitted to . . .	2277	4391
	1st Absorption band	2277 to 2673	4391 to 3741
	Spectrum transmitted from 2673 to .	2768	3612
	1 milligram-molecule in 2,500 c.c.		
5	Spectrum continuous to	2789	3585
	Still weak in position of absorption band.		
4	Spectrum continuous to . . .	2789	3585
	2nd Absorption band	2789 to 3282	3585 to 3047
	Spectrum very feebly transmitted from 3282 to	3309	3022
3	Spectrum continuous to . . .	2884	3467
	2nd Absorption band	2884 to 3282	3467 to 3047
	Spectrum very feebly transmitted from	3282 to 3341	3047 to 2993
2	Spectrum transmitted to . . .	2884	3467
	2nd Absorption band	2884 to 3148	3467 to 3177
	Lines showing faintly in the band of absorption at	2982, 3042, and 3064	3353, 3287, and 3264
	Spectrum feebly transmitted from 3148 to	3471	2881
	1 milligram-molecule in 12,500 c.c.		
5	Spectrum practically continuous to .	4405	2270
	Weak beyond	3471	2881
	Still weak in position of absorption band.		
4 to 1	Spectrum practically all transmitted, gradually getting stronger.		

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Berberine Nitrate.

$C_{20}H_{17}NO_4.HNO_3$.

Aqueous Solution.

(Fig. 9.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 to 1	Spectrum practically all absorbed.		
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum practically all absorbed.		
4 and 3	Spectrum transmitted to . . .	2162	4625
2	" " . . .	2162	4625
	1*st Absorption band*	2162 to 2463	4625 to 4060
	Weak spectrum from 2463 to . .	2673	3741
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	2714	3684
	Still weak in position of 1st absorption band.		
	2nd Absorption band	2714 to 3295	3684 to 3034
	Spectrum feebly transmitted from 3295 to	3323	3009
4	Spectrum continuous to . . .	2768	3612
	2nd Absorption band	2768 to 3295	3612 to 3034
	Spectrum feebly transmitted from 3295 to	3354	2981
3	Spectrum transmitted to . . .	2768	3612
	2nd Absorption band	2768 to 3148	3612 to 3176
	Spectrum feebly transmitted from 3148 to	3354	2981
2	Spectrum transmitted to . . .	2768	3612
	2nd Absorption band	2768 to 3148	3612 to 3176
	Lines showing faintly in absorption band at	2982, 3042, and 3064	3353, 3287, and 3263
	Spectrum feebly transmitted from 3148 to	3638	2748
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum practically continuous to .	4405	2270
	Weak beyond	3638	2748
	Still weak in position of absorption band.		
	Lines showing faintly at . . .	4533	2206
4 to 1	Spectrum practically all transmitted and gradually getting stronger.		

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Corydic Acid.

$C_{14}H_9N(OCH_3)_2(CO_2H)_2 + \frac{1}{2}H_2O$. M.P. 218°.

Aqueous Solution.

(Fig. 10.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 and 4	Spectrum continuous to . . .	2244	4456
3 and 2	„ „ . . .	2273	4399
	1 *milligram-molecule in* 500 *c.c.*		
5 to 2	Spectrum continuous to . . .	2354	4248
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	2508	3987
	Absorption band	2508 to 2982	3987 to 3353
	Spectrum feebly transmitted from 2982 to	3323	3009
4	Spectrum transmitted to . . .	2508	3987
	Absorption band	2508 to 2982	3987 to 3353
	Spectrum transmitted from 2982 to .	3323	3009
	Very feeble prolongation to . . .	3886	2573
3	Spectrum continuous to . . .	2508	3987
	Absorption band	2508 to 2884	3987 to 3467
	Spectrum very feebly transmitted from 2884 to	4408	2267
2	Spectrum practically continuous to . Very weak in position of absorption band.	4408	2267
1	Spectrum practically all transmitted, but still weak towards the end.		
	1 *milligram-molecule in* 12,500 *c.c.*		
5 to 1	Same as 1 mm. above, but gradually getting stronger.		

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Berberidic Acid.

$C_{13}H_7N(CH_2O_2)(CO_2H)_2$. M.P. 285°.

Aqueous Solution.

(Fig. 11.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5, 4, and 3	Spectrum continuous to . . .	2157	4636
2	„ „ . . .	2207	4531
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum continuous to . . .	2276	4393
3 and 4	„ „ . . .	2303	4342
2	„ „ . . .	2354	4248
	Absorption band	2354 to 2982	4248 to 3353
	Weak spectrum from 2982 to . .	3148	3176
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	2508	3987
	Absorption band	2508 to 2982	3987 to 3353
	Weak spectrum from 2982 to . .	3323	3009
4	Spectrum continuous to . . .	2508	3987
	Absorption band	2508 to 2982	3987 to 3353
	Weak spectrum from 2982 to . .	3323	3009
3	Spectrum continuous to . .	2508	3987
	Absorption band	2508 to 2884	3987 to 3467
	A few lines showing in the absorption band.		
	Spectrum continuous from 2884 to .	3872	2582
	Weak beyond	3872	2582
2	Spectrum continuous to . . .	4414	2265
	Weak in position of absorption band, and beyond	3872	2582
1	Spectrum practically all transmitted, but still weak.		
	1 *milligram-molecule in* 12,500 *c.c.*		
5 to 1	Same as 1 mm. of last plate, but gradually getting stronger.		

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Veratric Acid.

$C_6H_2(OCH_3)_2CO_2H. + 2H_2O$. M.P. 179–180°.

Solution in Alcohol.

(Fig. 12.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 to 2	Spectrum continuous to . . .	3191	3134
1	" " . . .	3191	3134
	Very faint prolongation to . . .	3246	3080
	1 *milligram-molecule in* 500 *c.c.*		
4 and 5	Spectrum continuous to . . .	3246	3080
3	" " . . .	3296	3034
	Absorption band	3296 to 4230	3034 to 2364
	Weak spectrum from 4230 to . .	4321	2314
	Line showing faintly at . . .	4321	2314
2	Spectrum continuous to . . .	3323	3009
	1*st Absorption band*	3323 to 3521	3009 to 2840
	Very faint spectrum from 3521 to .	3638	2749
	2*nd Absorption band*	3638 to 4240	2749 to 2358
	Weak spectrum from 4240 to . .	4321	2314
1	Spectrum transmitted to . . .	3354	2981
	1*st Absorption band*	3354 to 3471	2981 to 2881
	Weak spectrum from 3471 to . .	3694	2707
	2*nd Absorption band*	3694 to 4106	2707 to 2435
	Weak spectrum from 4106 to . .	4407	2269
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum transmitted to . . .	3354	2981
	1*st Absorption band*	3354 to 3471	2981 to 2881
	Spectrum from 3471 to	3694	2707
	2*nd Absorption band*	3694 to 4106	2707 to 2435
	Weak spectrum from 4106 to . .	4407	2269
4	Spectrum transmitted to . . .	3694	2707
	Very weak in position of 1st absorption band.		
	2*nd Absorption band*	3694 to 4106	2707 to 2435
	Weak spectrum from 4106 to . .	4407	2269
3	Spectrum practically continuous to .	3886	2573
	Weak in position of absorption band.		
	2*nd Absorption band*	3886 to 4106	2573 to 2435
	Lines showing faintly in 2nd absorption band at	4018, 4088, and 3994	2488, 2476, and 2504
	Weak spectrum from 4106 to . .	4407	2269
2	Spectrum transmitted to . . .	4407	2269
	Very weak in position of 2nd absorption band.		
1	Spectrum all transmitted.		

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Piperonylic Acid.

$C_6H_3(CH_2O_2)CO_2H$. M.P. 225°.

Solution in Alcohol.

(Fig. 13.)

Thickness of layer in millimetres	Description of spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25,20,15 and 10	Spectrum continuous to . . .	3148	3177
5	" " . . .	3191	3134
	Lines at	3638, 4230, and 4300	2749, 2364, and 2325
4	Spectrum continuous to . . .	3191	3134
	Lines at	3560, 3630, 4230 & 4350	2809, 2755, 2364 & 2299
3	Spectrum continuous to . . .	3191	3134
	1st Absorption band	3191 to 3520	3134 to 2840
	Weak spectrum from 3520 to . .	3630	2755
	2nd Absorption band	3630 to 4102	2755 to 2439
	Weak spectrum from 4102 to . .	4402	2272
	Spectrum continuous to . . .	3191	3134
	1st Absorption band	3191 to 3471	3134 to 2881
	Weak spectrum from 3471 to . .	3678	2719
	2nd Absorption band	3678 to 4098	2719 to 2440
	Weak spectrum from 4098 to . .	4402	2272
1	Spectrum continuous to . . .	4402	2272
	Weak in position of 1st absorption band.		
	Very weak in position of 2nd absorption band.		
	1 *milligram-molecule in* 2·500 *c.c.*		
5 and 4	Spectrum continuous to . . .	4402	2272
	Weak in position of 1st absorption band		
	" " 2nd " "		
3	Continuous to	4402	2272
	Still weak in position of absorption band.		
2 and 1	Spectrum practically continuous.		

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CORYDALDINE.

$C_9H_7NO(OCH_3)_2$. M.P. 175°.

Aqueous Solution.

(Fig. 14.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 to 1	Spectrum transmitted to . . .	3064	3264
	1 *milligram-molecule* in 500 *c.c.*		
5	Spectrum continuous to . . .	3064	3264
	Lines faintly transmitted . . .	3148	3177
4 and 3	Spectrum transmitted to . . .	3148	3177
2	" " . . .	3148	3177
	Absorption band	3148 to 3494	3177 to 2863
	Very feeble spectrum from 3494 to .	3638	2749
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	3182	3143
	Absorption band	3132 to 3482	3148 to 2872
	Lines showing faintly in band . .	3295 & 3323	3035 & 3009
	Very feeble spectrum from 3482 to .	3638	2749
	Lines faintly transmitted , . .	4110 & 4124	2433 & 2425
4	Spectrum practically continuous to .	4321	2314
	Very weak beyond	3638	2749
	Very weak in position of absorption band.		
3	Same as 4 m.m. but stronger. Band still perceptible.		
2 and 1	Spectrum transmitted to . . .	4412	2266
	Still weak beyond	3638	2749
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum continuous to . . .	4533	2206
4	" " . . .	4656	2148
3, 2, and 1	Spectrum practically all transmitted.		

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ω-Aminomethylpiperonylcarboxylic Anhydride.

$C_9H_7NO(CH_2O_2)$. M.P. 181–182°.

Solution in Alcohol.

(Fig. 15.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5	Spectrum continuous to . . .	2884	3467
	Lines showing at	2982	3353
4	Spectrum continuous to . . .	2982	3353
3	„ „ . . .	3002	3331
2	„ „ . . .	3064	3264
	1 *milligram-molecule in* 500 *c.c.*		
5, 4, 3	Spectrum transmitted to . . .	3064	3264
2	„ „ . . .	3148	3177
	Absorption band	3148 to 3521	3177 to 2840
	Weak spectrum from 3521 to . .	3638	2749
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	3148	3177
	Absorption band	3148 to 3471	3177 to 2881
	Lines faintly transmitted in absorption band at	3295 & 3323	3035 & 3009
	Weak spectrum from 3471 to . .	3886	2573
	Lines faintly transmitted at . .	4111 & 4130	2432
4 and 3	Spectrum practically transmitted to .	4321	2314
	Weak beyond	3638	2749
	Position of absorption band still clearly perceptible.		
2	Spectrum transmitted to . . .	4412	2266
1	„ „ . . .	4656	2148
	1 *milligram-molecule in* 12,500 *c.c.*		
5 to 1	Spectrum practically all transmitted.		

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HYDRASTININE.

$C_{11}H_{13}NO_3$. M.P. 115°.

Solution in Alcohol.

(Fig. 16.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25, 20, and 15	Spectrum transmitted to	2502	3997
	1st Absorption band	2502 to 2892	3997 to 3459
	Weak spectrum transmitted from 2892 to	3148	3177
10	Spectrum transmitted to	2502	3997
	Faint prolongation to	2542	3934
	1st Absorption band	2542 to 2864	3934 to 3467
	Weak spectrum transmitted from 2884 to	3148	3467
5	Spectrum transmitted to	3148	3177
	Weak in position of 1st absorption band		
	2nd Absorption band	3148 to 3638	3177 to 2749
	Weak spectrum transmitted from 3638 to	3824	2615
4	Spectrum transmitted to	3296	3034
	2nd Absorption band	3296 to 3638	3034 to 2749
	Weak spectrum transmitted from 3638 to	3824	2615
3	Spectrum transmitted to	3296	3034
	2nd Absorption band	3296 to 3638	3034 to 2749
	Weak spectrum transmitted from 3638 to	3824	2615
	Line in absorption band at	3568	2803
2	Spectrum transmitted to	3296	3034
	2nd Absorption band	3296 to 3521	3034 to 2840
	Spectrum transmitted from 3521 to	3824	2615
	3rd Absorption band	3824 to 4114	2615 to 2431
	Very weak spectrum transmitted from 4114 to	4420	2262
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum transmitted to	3886	2573
	Still weak in position of 2nd absorption band.		
	3rd Absorption band	3886 to 4114	2573 to 2431
	Spectrum transmitted from 4114 to	4555	2195
4	Spectrum transmitted to	3886	2573
	3rd Absorption band	3886 to 4114	2573 to 2431
	Spectrum transmitted from 4114 to	4555	2195
3 and 2	Spectrum transmitted to	4656	2148
	Weak in position of 3rd absorption band.		
1	Spectrum all transmitted.		

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Oxyhydrastinine.

$C_{10}H_9NO(CH_2O_2)$. M.P. 97–98°.

Solution in Alcohol.

(Fig. 17.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 to 1	Spectrum continuous to . . .	3064	3264
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum transmitted to . . .	3064	3264
4	" " . . .	3064	3264
	Line faintly transmitted at . . .	3568	2803
3	Spectrum transmitted to . . .	3064	3264
	Absorption band	3034 to 3521	3264 to 2840
	Spectrum feebly transmitted from 3521 to	3638	2749
2	Spectrum transmitted to . . .	3148	3177
	Absorption band	3148 to 3482	3177 to 2872
	Weak spectrum from 3482 to . .	3638	2749
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	3148	3177
	Absorption band	3148 to 3482	3177 to 2872
	Spectrum transmitted from 3482 to .	4321	2314
	Very weak beyond	3638	2749
	Lines showing feebly in bands at .	3295 & 3323	3035 & 3009
4	Spectrum practically transmitted to .	4321	2314
	Weak towards end and in the position of absorption band.		
3	Same as 4 mm., but stronger.		
2	Spectrum transmitted to	4406	2269
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum continuous to	4555	2195
	Weak towards end.		
4 to 1	Spectrum practically all transmitted and getting stronger.		

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Quinine.[1]

$C_{20}H_{24}N_2O_2$. M.P. 172–173°.

Solution in Alcohol.

(Fig. 18.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5	Spectrum transmitted to . . .	2802	3569
4, 3, and 2	„ „ . . .	2884	3467
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum transmitted to . . .	2905	3442
4	„ „ . . .	2938	3403
	1*st Absorption band*	2938 to 3300	3403 to 3030
	Weak spectrum from 3300 to . .	3330	3003
	2*nd Absorption band*	3330 to 3837	3003 to 2606
	Very weak spectrum from 3837 to .	3890	2570
3	Spectrum transmitted to . . .	2938	3403
	1*st Absorption band*	2938 to 3300	3403 to 3030
	Spectrum from 3300 to	3350	2985
	2*nd Absorption band*	3350 to 3837	2985 to 2606
2	Spectrum transmitted from 3837 to .	2938	3404
	1*st Absorption band*	2938 to 3295	3404 to 3035
	Lines faintly showing where the 2nd absorption band occurred . .	2982, 3046, 3295 & 3923	3353, 3282, 3035 & 2549
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum transmitted to . . . . Weak in position of 1st absorption band.	4006	2496
4, 3, 2	Spectrum transmitted to . . . Weak transmission in position of 1st absorption band.	4038	2476
1	Spectrum practically all transmitted, but weak beyond.	4038	2476

Quinidine[2] and Cuprbine.

The spectra of quinidine and cupreine are identical with those of quinine.

Hydroquinine.

$C_{20}H_{26}N_2O_2$.

The spectra of hydroquinine resembled those of quinine so closely that no separate curve was drawn.

[1] Hartley, *Phil. Trans.*, 1885, Part II., p. 471. [2] Hartley, *loc. cit.*

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Cinchonine.[1]

$C_{19}H_{22}N_2O$. M.P. 255–255°·5.

Solution in Alcohol.

(Fig. 19.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25, 20, 15	Spectrum transmitted to . . .	3076	3251
10	„ „ . . .	3118	3207
5	„ „ . . .	3148	3177
	Lines showing feebly at . . .	4117 & 4130	2429 & 2421
4 and 3	Spectrum transmitted to . . .	3148	3177
	Absorption band	3148 to 3886	3177 to 2573
	Very weak spectrum transmitted from 3886 to . .	4130	2421
2	Spectrum transmitted to . .	3148	3177
	Absorption band	3148 to 3824	3177 to 2615
	Weak spectrum transmitted from 3824 to	4175	2395
	Line feebly transmitted in absorption band	3295	3035
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum transmitted to . . .	4175	2395
	Weak in position of absorption band.		
4 and 3	Spectrum transmitted to . . .	4250	2353
	Weak in position of absorption band.		
2	Spectrum transmitted to . . .	4250	2353
1	„ „ . . .	4418	2263
	1 *milligram-molecule in* 12,500 *c.c.*		
4 to 1	Spectrum all transmitted		

Cinchonidine.[2]

$C_{19}H_{22}N_2O$. M.P. 202°.

The spectra of cinchonidine are identical with those of cinchonine.

[1] Hartley, *Phil. Trans.*, 1885, Part 1 p. 471. [2] Hartley, *loc. cit.*

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MORPHINE.[1]

$C_{17}H_{19}NO_3 + H_2O$.

Solution in Alcohol.

(Fig. 1.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c.*		
5 and 4	Spectrum continuous to . . .	3323	3009
3	„ „ . . .	3323	3009
	Line showing faintly at . . .	3824	2615
2	Spectrum continuous to . . .	3354	2981
	Absorption band	3354 to 3753	2981 to 2664
	Lines showing faintly at . . .	3824 & 3886	2615 & 2573
	1 *milligram-molecule in* 500 *c.c.*		
5	Spectrum continuous to . . .	3354	2981
	Absorption band	3354 to 3638	2981 to 2749
	Weak spectrum from 3638 to . .	3886	2573
4	Spectrum continuous to . . .	3354	2981
	Absorption band	3354 to 3638	2981 to 2749
	Lines faintly transmitted in absorption band at	3471 & 3568	2881 & 2803
	Spectrum continuous from 3658 to .	3886	2573
3 and 2	Spectrum practically transmitted to .	3926	2547
	But still very weak in position of absorption band.		
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	4320	2315
	Very weak beyond	3886	2573
4, 3, and 2	Spectrum continuous to . . .	4414	2265
	Very weak beyond	3886	2573
1	Spectrum all transmitted.		

CODEINE.[2]

$C_{18}H_{21}NO_3$. M.P. 153°·5.

The spectra of codeine are nearly identical with those of morphine.

[1] Hartley, *Phil. Trans.*, 1885, Part II., p. 471. [2] Hartley, *loc. cit.*

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Corybulbine.

$C_{21}H_{25}NO_4$. M.P. 223–225°.

Solution in Alcohol.

(Fig. 20.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 1,000 *c.c.*		
50, 40, and 30	Spectrum transmitted to . . .	3296	3033
20	„ „ . . .	3323	3009
10 and 8	„ „ . . .	3323	3009
	Absorption band	3323 to 3815	3009 to 2621
	Rather feeble spectrum from 3815 to .	4017	2489
6	Spectrum transmitted to . . .	3334	2999
	Absorption band	3334 to 3740	2999 to 2673
	Spectrum feebly transmitted from 3740 to	4028	2482
4	Spectrum transmitted to . . .	3334	2999
	Absorption band	3334 to 3638	2999 to 2748
	Weak spectrum from 3638 to . .	4104	2436
	1 *milligram-molecule in* 2,500 *c.c.*		
5 and 4	Spectrum transmitted to . . .	4117	2428
	Very weak in position of absorption band.		
3	Spectrum transmitted to . . .	4403	2271
	Very weak beyond	4117	2428
2	Same as 3 mm., with additional line showing at	4495	2224
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum transmitted to . . .	4549	2198
4 to 1	Spectrum all transmitted.		

Bulbocapnin.

$C_{19}H_{19}NO_4$. M.P. 201°.

Solution in Alcohol.

(Fig. 21.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25	Spectrum continuous to . . .	2938	3403
20 and 15	„ „ . . .	2982	3353
10	„ „ . . .	3013	3318
5	„ „ . . .	3064	3263
4	„ „ . . .	3064	3263
3 and 2	„ „ . . .	3076	3250

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BULBOCAPNIN—*continued.*

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 2,500 *c.c.*		
5	Spectrum continuous to . . .	3521	2840
	Absorption band	3521 to 3886	2840 to 2573
	Very weak spectrum from 3886 to .	4038	2476
4	Spectrum continuous to . . .	3521	2840
	Absorption band	3521 to 3886	2840 to 2573
	Spectrum from 3886 to	4128	2422
	Lines in absorption band feebly shown at	3568, 3638, and 3824	2802, 2748, and 2615
3	Spectrum continuous to . . .	3638	2748
	Absorption band	3638 to 3824	2748 to 2615
	Weak spectrum from 3824 to . .	4128	2422
2	Spectrum practically continuous to . Weak in position of absorption band.	3824	2615
	Spectrum practically transmitted to .	4656	2147
	1 *milligram-molecule in* 12,500 *c.c.*		
	Spectrum all transmitted.		

NARCEINE.[1]

$C_{23}H_{27}NO_8 + 3H_2O$. M.P. 145°.

Solution in Alcohol.

(Fig. 22.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25	Spectrum continuous to	3002	3331
20 and 15	„ „	3076	3251
10 and 5	„ „	3148	3177
4	„ „	3191	3134
3 and 2	„ „	3323	3009
	1 *milligram-molecule in* 2,500 *c.c.*		
5 and 4	Spectrum transmitted to . . . But very weak beyond.	3886	2573
3	Spectrum transmitted to . . . Very weak beyond.	4123	2425
2	Spectrum transmitted to . . . Very weak beyond.	4411	2267
	1 *milligram-molecule in* 12,500 *c.c.*		
5	Spectrum continuous to . . .	4536	2204
	Very weak beyond	4411	2267
4 and 3	Spectrum transmitted to . . .	4555	2195
	Very weak beyond	4411	2267
2 and 1	Spectrum practically all transmitted.		

[1] Hartley, *Phil. Trans.*, 1885, Part II., p. 471.

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The Absorption Spectra of Laudanine and Laudanosine in Relation to their Constitution.[1] *By* JAMES J. DOBBIE, *D.Sc., M.A., and* ALEXANDER LAUDER, *B.Sc.*

It has been shown that alkaloids which only differ from one another in minor details of structure give similar absorption curves, whilst those which differ widely in structure give correspondingly different series of spectra. So far, no case has yet been encountered in which two substances

FIG. 23.—Laudanosine, $C_{21}H_{27}O_4N$. (*In alcoholic solution.*)

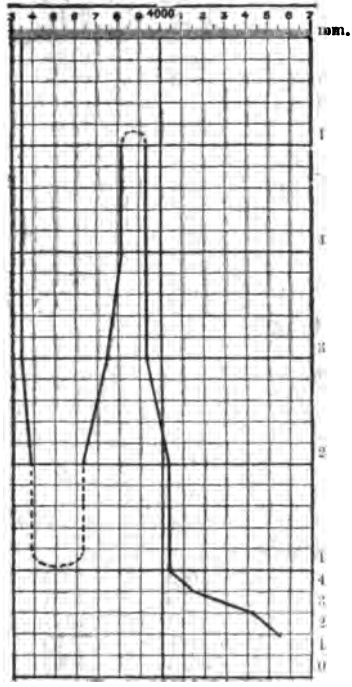
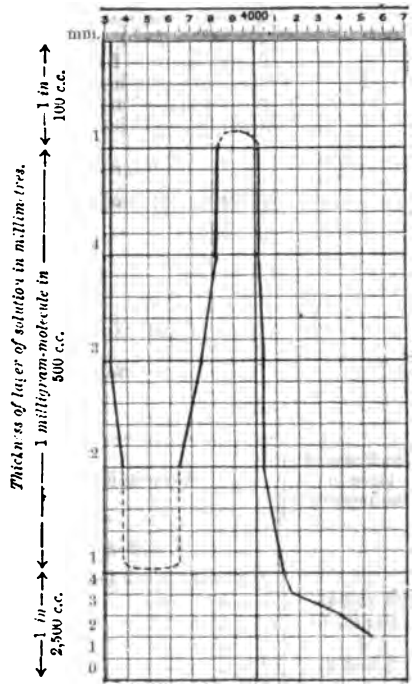


FIG. 24.—Laudanine, $C_{20}H_{25}O_4N$. (*In alcoholic solution.*)


Scale of oscillation-frequencies.
4000
mm.
Thickness of layer of solution in millimetres.
1 in — 100 c.c.
1 milligram-molecule in — 500 c.c.
1 in — 2,500 c.c.

known to differ substantially in structure give an identical or nearly identical series of spectra.

This principle finds an interesting application in the case of laudanine, $C_{20}H_{25}O_4N$, and laudanosine, $C_{21}H_{27}O_4N$, two rare alkaloids separated by Hesse [2] from opium. These differ from one another by CH_2, and since the former contains three, and the latter four methoxyl groups, it has been assumed that the substances are homologous, although the conversion of laudanine into laudanosine has not yet been accomplished. If this view of their relation is correct, they should give practically identical absorption curves, and this we have found to be actually the case, the

[1] *Chem. Soc. Trans.*, 1903, **83**, 626.
[2] *Annalen*, 1870, **77**, 47; *Suppl.*, 1872, **8**, 261.

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measurements of the photographs of the two series of spectra agreeing almost perfectly.

The investigation of these compounds was undertaken solely with reference to their suspected homology, but it was at once seen, on examining their spectra, that a close resemblance subsisted between them and the spectra of corydaline and tetrahydropapaverine. The photographs of the spectra of corydaline and laudanosine in particular are almost indistinguishable, and suggest a very close structural relation between these two compounds. Laudanosine differs from tetrahydropapaverine by CH_2, and may simply be a homologue of this substance, possibly having a methyl group attached to carbon atom 4. (See papaverine, p. 127.)

Apart from the closer resemblance of their spectra, however, there is some ground for believing that laudanosine is more nearly related to corydaline than to tetrahydropapaverine. It differs from corydaline only in having one atom of carbon less in its molecule; the two substances cannot therefore be homologous, if the formulæ of both have been correctly determined.

Corydaline has recently been analysed by numerous investigators, with concordant results, and its formula may be regarded as well established. Laudanine and laudanosine, on the other hand, have been but little examined, and there is a possibility that their formulæ may not yet have been definitely settled. Assuming, however, as we are bound to do for the present, that the analyses are correct, cases are known in which substances, other than homologues, which are nearly related structurally, show as close an agreement between their spectra even when their formulæ differ more widely than those of corydaline and laudanosine.

Unfortunately, very little is known of the chemistry of laudanosine, but that little is entirely in favour of the view expressed as to its close relationship with corydaline and tetrahydropapaverine. Like those substances, it contains four methyl groups, and yields metahemipinic acid as one of its products of oxidation. It further resembles corydaline in being optically active and in the ease with which, when heated with dilute nitric acid, it undergoes oxidation to a yellow base. This substance, which has not been analysed, may be identical with meconidine,[1] an alkaloid associated with laudanosine in opium. The formula of meconidine, $C_{21}H_{23}O_4N$, bears the same relation to that of laudanosine that the formulæ of dehydrocorydaline and berberine bear to those of corydaline and tetrahydroberberine respectively, as the following table shows :—

Colourless.	*Yellow.*
Corydaline, $C_{22}H_{27}O_4N$, m.p. 135°·5.	Dehydrocorydaline, $C_{22}H_{23}O_4N$, m.p. 118–120°.
Tetrahydroberberine, $C_{20}H_{21}O_4N$, m.p. 167°.	Berberine, $C_{20}H_{17}O_4N$, m.p. 145°.
Laudanosine, $C_{21}H_{27}O_4N$, m.p. 89°.	Meconidine, $C_{21}H_{23}O_4N$, m.p. 58°.

[1] Hesse, *Annalen*, 1870, 77, p. 47.

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Whether the yellow substance produced by the oxidation of laudanosine is identical or not with meconidine, the mere fact of the existence of a coloured base in opium having a formula differing from that of laudanosine by four atoms of hydrogen lends some support to the view of the relationship of these substances set forth in this paper, and this hypothesis receives some additional support from a comparison of the melting-points of the substances. The question, however, as to whether laudanosine is more closely related to corydaline or to tetrahydroberberine can only be settled by further chemical investigation.

The point which we wish to emphasise is that it must, from the similarity of the curve plotted from its spectra, be built on the same plan as these two closely related compounds.

LAUDANOSINE.

$C_{21}H_{27}NO_4$. M.P. 89°.

Solution in Alcohol.

(Fig. 23.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25, 20, 15 & 10	Spectrum transmitted to . . .	3323	3009
5	„ „ . . .	3354	2982
	Absorption band	3354 to 3824	2982 to 2615
	Spectrum transmitted from 3824 to .	3930	2544
4	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3824	2981 to 2615
	Spectrum transmitted from 3824 to .	3930	2544
3	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3754	2981 to 2664
	Spectrum transmitted from 3754 to .	3930	2544
	Line faintly showing at . . .	4003	2498
2	Spectrum transmitted to . . .	3388	2951
	Absorption band	3388 to 3638	2951 to 2749
	Spectrum transmitted from 3638 to .	4038	2476
1	Spectrum transmitted to . . .	4038	2476
	But very weak in position of absorption band.		
	1 *milligram-molecule in* 2,500 *c.c.*		
4	Spectrum transmitted to . . .	4115	2430
3	„ „ . . .	4428	2258
2	„ „ . . .	4555	2195
1	„ all transmitted . . .		
	1 *milligram-molecule in* 12,500 *c.c.*		
4 to 1	Spectrum all transmitted.		

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LAUDANINE.

$C_{20}H_{25}NO_4$.

Solution in Alcohol.

(Fig. 24.)

Thickness of layer in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 *c.c.*		
25, 20, and 15	Spectrum transmitted to . . .	3323	3009
10	„ „ . . .	3323	3009
	Line showing at	3386	2573
5	Spectrum transmitted to . . .	3354	2982
	Absorption band	3354 to 3824	2982 to 2615
	Spectrum transmitted from . . .	3824 to 4003	2615 to 2498
4	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3824	2981 to 2615
	Spectrum transmitted from . . .	3824 to 4003	2615 to 2498
	Faint indications of lines from . .	3754 to 3824	2664 to 2615
	and from	4003 to 4038	2498 to 2476
3	Spectrum transmitted to . . .	3354	2981
	Absorption band	3354 to 3754	2981 to 2664
	Spectrum transmitted from . . .	3754 to 4038	2664 to 2476
2	Spectrum transmitted to . . .	3382	2957
	Absorption band	3382 to 3654	2957 to 2737
	Spectrum transmitted from . . .	3654 to 4026	2737 to 2484
1	Spectrum transmitted to . . .	4128	2422
	Very weak in position of absorption band.		
	1 *milligram-molecule in* 2,500 *c.c.*		
4	Spectrum transmitted to . . .	4115	2430
3	„ „ . . .	4428	2258
2	„ „ . . .	4555	2195
1	„ all transmitted . . .		
	1 *milligram-molecule in* 12,500 *c.c.*		
4 to 1	Spectrum all transmitted.		

On the Possibility of Making Special Reports more available than at present.—Report of the Committee, consisting of Mr. W. A. SHENSTONE (*Chairman*), Dr. M. O. FORSTER (*Secretary*), Professor E. DIVERS, Professor W. J. POPE, *and* Dr. A. W. CROSSLEY.

The Committee recommend :—

1. That at the close of each annual meeting the Sectional Committee shall request its secretaries to compile a list of the Special Reports, other than those of Standing Committees, which have been presented to the Section during the previous five years, and which have been published *in extenso*, this list (see Appendix) to include those Reports of the character specified which have been presented at the annual meeting just terminated.

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2. That the secretaries of the Sectional Committee be requested to forward copies of the list to the secretaries of the Chemical Societies of London and Berlin, with the suggestion that the councils of these bodies might be disposed to bring such Reports to the notice of Fellows by inserting the references in one of the issues of their publications.

APPENDIX.

List of Special Reports presented to Section B during 1898–1902, indicating the type of Special Report to which attention might be drawn in the manner indicated by the Committee :—

1900. 'The Constitution of Camphor.' By A. LAPWORTH.
1901. 'Methods of Determining the Hydrolytic Dissociation of Salts.' By R. C. FARMER.
'On the Equilibrium Law as applied to Salt Separation and to the Formation of Oceanic Salt Deposits.' By E. F. ARMSTRONG.
1902. 'Hydro-aromatic Compounds with Single Nucleus.' By A. W. CROSSLEY.
'Our Present Knowledge of Aromatic Diazo- Compounds.' By G. T. MORGAN.

Duty-free Alcohol for Scientific Research.—Report of the Committee, consisting of Sir H. E. ROSCOE (*Chairman*), Professor H. B. DIXON (*Secretary*), Sir MICHAEL FOSTER, Sir A. W. RÜCKER, Dr. T. E. THORPE, Professor W. H. PERKIN, *and* Professor W. D. HALLIBURTON.

THE Committee appointed at the Glasgow meeting in 1901 were unable to report in 1902, as they were at the time of the Belfast meeting in the midst of their negotiations with the Board of Inland Revenue.

After a preliminary meeting and correspondence in the winter of 1901–2 the Committee received information that the Government were willing to adopt a clause in the Budget Bill of 1902 which would permit the use of duty-free alcohol under conditions to be laid down by the Board of Inland Revenue. When the Budget Bill was passed a deputation from the Committee waited on the Chairman of the Board, and after full discussion the Committee agreed to confine their application at the present time to the use of duty-free alcohol (ethyl and methyl) and of alcoholic derivatives for the purposes of research work and higher teaching in the laboratories of universities, colleges, and public institutions.

At the request of the Chairman of the Board of Inland Revenue the Committee drew up the following statement :—

'*To the Chairman of the Board of Inland Revenue.*

'August 6, 1902.

'SIR,—At the meeting of the British Association held at Glasgow last year a Committee was appointed to approach the Inland Revenue Com-

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missioners to urge the desirability of securing the use of pure alcohol duty-free for the purposes of scientific research.

'It was pointed out at the Glasgow meeting that the low price of pure alcohol and its derivatives on the Continent and the high duty payable in the United Kingdom severely handicapped research workers here in chemistry, physiology, and pathology, and to a smaller extent in zoology and botany. In the recent debates on the Budget Bill this disadvantage was recognised, and steps were taken with a view to remedy the evil.

'In the United States, where alcohol is taxed, permits are granted to scientific institutions of certain rank enabling them to obtain duty-free alcohol for use in their laboratories. The conditions under which these permits are granted by the United States Treasury have been obtained by this Committee. A copy of these regulations was placed in your hands at the interview you were good enough to grant on the 9th inst. to members of this Committee.

'In accordance with your request we have obtained some statistics as to the amount of alcohol (and its derivatives) used in English laboratories for higher teaching and research work. It has not been possible to obtain complete details, but the following figures, which are the average number of *gallons* used per annum during the last three years in the laboratories at Cambridge, at Owens College, and the Yorkshire College, may be taken as typical :—

—	Absolute Ethyl Alcohol	Rectified Spirit	Absolute Methyl Alcohol	Ethyl Ether	Methylated Spirit
I. CAMBRIDGE. (University and College Laboratories.)					
Chemical Laboratories	30	30	—	60	500
Pathological „	15	—	—	10	
Physiological „	10	10	—	10	
Zoological and Botanical Laboratories	20	—	—	—	
II. OWENS COLLEGE.					
Chemical Laboratories	50	—	20	80	100
Pathological „	15	—	—	5	5
Physiological „	5	—	—	—	25
Zoological and Botanical Laboratories	5	—	—	1	120
III. YORKSHIRE COLLEGE.					
Chemical Laboratories	15	—	12	25	50
Medical Department	—	—	—	—	150

It should be pointed out that if pure alcohol could be obtained duty-free more would be used in scientific work instead of the methylated spirit now used whenever possible.

'From the table given it will be seen that the chief demand in scientific laboratories is for pure ethyl alcohol and pure ethyl ether. But other alcohols (*e.g.* methyl alcohol) and other derivatives of alcohols (*e.g.* methyl and ethyl iodides) and ethereal salts (*e.g.* malonic ether) are largely used in organic chemistry. These reagents are at present mainly imported

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from Germany and pay duty to the Customs. There is therefore a desire that such ethereal compounds might be imported duty-free for scientific use.

'In the request that we now make for the use of duty-free ethyl alcohol and its derivatives, for the purpose of higher teaching and research, we would point out that the alcohol (or other reagent) is destroyed or contaminated beyond recovery by the use to which it is put, and such destruction or contamination could be certified by the director of the laboratory.

'In the opinion of the Committee there would be no difficulty in arranging for one distributing station in each university centre to supply the several laboratories of that centre.'

On October 22 the Committee received from the Board a draft of the suggested regulations under which it was proposed to authorise the issue, in accordance with section 8 of the Finance Act, 1902, of pure spirit duty-free for purposes of scientific research and education. The Board asked for observations on the proposed regulations.

The Committee had copies of these proposed regulations sent to the directors of the chief laboratories in the country, with a request that they would forward any suggestions they might wish to make to the Committee. After considering the suggestions sent in, the Committee submitted their observations to the Board, who adopted the alterations suggested, and informed the Committee that *methyl alcohol* might be obtained under the same regulations.

The Committee, with the permission of the Board of Inland Revenue, published the regulations in 'The Times' and other newspapers with the accompanying explanatory letter :—

'*Duty-free Alcohol for Research.*

'To the Editor of "The Times."'

'December 15, 1902.

'SIR,—It has long been felt by scientific workers in this country that a serious drawback to the prosecution of research lies in the fact that the full and very heavy duty has to be paid on pure alcohol, as distinguished from methylated spirit, largely used in scientific laboratories where higher teaching and research are carried on. And this appeared to be a hardship in the first place because the alcohol thus used is either destroyed or rendered useless for potable purposes, and in the second place because no such duty is paid in Germany, France, or the United States, and thus the British is heavily handicapped as against the foreign worker.

'At the meeting of the British Association held last year in Glasgow, a Committee was appointed with instructions to approach the Board of Inland Revenue with the object of endeavouring to secure the removal of this grievance—a grievance which was recognised by Government in the Budget Bill of this year. We are now glad to report that the Board has met our suggestions in the fairest possible manner with an obvious desire to extend facilities for scientific research in the direction indicated, as a perusal of the regulations which we enclose will show.

'The Secretary to the Board of Inland Revenue informs us that pure "methyl alcohol," also much used in chemical research, may be obtained under the same regulations, and should smaller quantities of methyl

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alcohol be required than the minimum permitted in the case of ethyl alcohol, the Board will consider special applications to that effect.—We are, &c.,

'H. E. ROSCOE, Chairman.
'H. B. DIXON, Secretary to the Committee.'

(Enclosure.)

Regulations for the Use of Duty-free Spirit at Universities, Colleges, &c.

1. An application must be made by the governing body or their representatives, stating the situation of the particular university, college, or public institution for research or teaching, the number of the laboratories therein, the purpose or purposes to which the spirits are to be applied, the bulk quantity likely to be required in the course of a year, and, if it amounts to fifty gallons or upwards, the name or names of one or more sureties, or a guarantee society to join in a bond that the spirits will be used solely for the purpose requested and at the place specified.

2. The spirits received at any one institution must only be used in the laboratories of that institution, and must not be distributed for use in the laboratories of any other institution, or used for any other purpose than those authorised.

3. Only plain British spirits or unsweetened foreign spirits of not less than 50 degrees over-proof (*i.e.* containing not less than 80 per cent. by weight of absolute alcohol) may be received duty-free, and the differential duty must be paid on the foreign spirits.

4. The spirits must be received under bond either from a distillery or from an Excise or Customs general warehouse, and (except with special permission) in quantities of not less than nine bulk gallons at a time. They will be obtainable only on presentation of a requisition signed by the proper supervisor.

5. On the arrival of the spirits at the institution the proper revenue officer should be informed, and the vessels, casks, or packages containing them are not to be opened until he has taken an account of the spirits.

6. The stock of spirits in each institution must be kept under lock in a special compartment under the control of a professor or some responsible officer of the university, college, or institution.

7. The spirits received by the responsible officer of the institution may be distributed by him undiluted to any of the laboratories on the same premises.

8. No distribution of spirits may be made from the receiving laboratory to other laboratories which are not within the same premises.

9. A stock-book must be provided and kept at the receiving laboratory, in which is to be entered on the debit side an account of the bulk and proof gallons of spirits received with the date of receipt, and on the credit side an account of the bulk and proof gallons distributed to the other laboratories. A stock-book must also be kept at each other laboratory, in which must be entered on the day of receipt an account of the bulk and proof gallons of spirits received from the receiving laboratory. These books must be open at all times to the inspection of the revenue officer, and he will be at liberty to make any extract from them which he may consider necessary.

10. The quantity of spirits in stock at any one time must not exceed

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half the estimated quantity required in a year where that quantity amounts to 20 gallons or upwards.

11. Any contravention of the regulations may involve the withdrawal of the Board's authority to use duty-free spirits.

12. It must be understood that the Board of Inland Revenue reserve to themselves full discretion to withhold permission for the use of duty-free spirit in any case in which the circumstances may not seem to them to be such as to warrant the grant of it.

NOTE.—'Proof spirit' is defined by law to be such as at the temperature of 51 degrees Fahrenheit shall weigh $\frac{12}{13}$ of an equal measure of distilled water. Taking water at 51 degrees Fahrenheit as unity, the specific gravity of 'proof spirit' at 51 degrees Fahrenheit is ·92308. When such spirit is raised to the more usual temperature of 60 degrees Fahrenheit, the specific gravity is ·91984. To calculate the quantity of spirits at proof in a given quantity of spirit over or under proof strength, multiply the quantity of spirit by the number of degrees of strength of the spirit and divide the product by 100. The number of degrees of strength of any spirit is 100 plus the number of degrees overproof, or minus the number of degrees underproof.

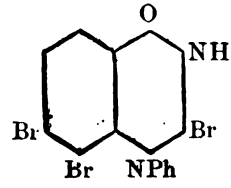
Example:

19·8 gallons of spirits at 64·5 overproof
100 + 64·5 = 164·5 proof strength.
164·5 × 19·8 ÷ 100 = 32·571
taken as 32·5 gallons at proof.

Isomeric Naphthalene Derivatives.—Report of the Committee, consisting of Professor W. A. TILDEN (*Chairman*) *and* Dr. H. E. ARMSTRONG (*Secretary*). (*Drawn up by the Secretary.*)

DURING the past year proof has been obtained of the structure of the series of higher brominated derivatives prepared from 1 : 5 : 6-tribromo-β-naphthol which were referred to in last year's report; these compounds were then represented by formulæ containing a bromine atom in position 3 marked with a query. The following facts show that a correct view was then taken as to the position of this bromine atom.

The tetrabromo-β-naphthol (m.p. 184°), from which the higher brominated compounds are derived, is convertible by nitric acid into a tribromo-β-naphthaquinone (m.p. 183°) which aniline converts into the compound



Such a substance can obviously only be formed from a quinone containing a bromine atom in position 3, not from one containing bromine in the

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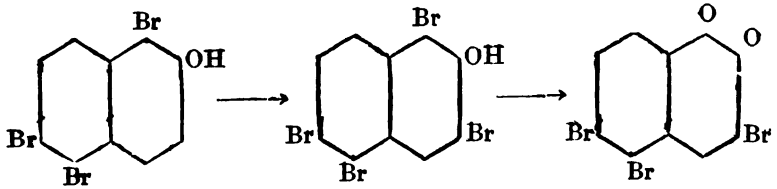
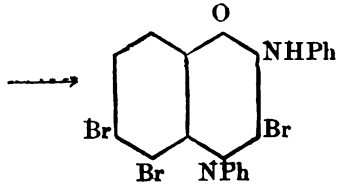
alternative position 4. The relationship of the several compounds is therefore as follows :—



Tribromo-β-naphthol, m.p. 159°. Tetrabromo β-naphthol, m.p. 184°. Tribromo-β-naphthaquinone, m.p. 183°.

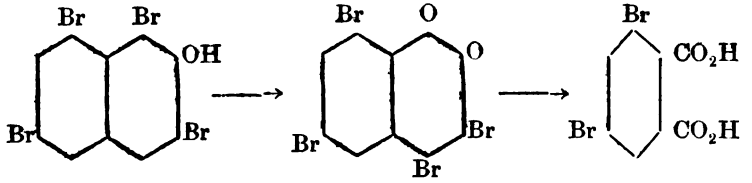


Anil.

The structure has also been determined of the tetrabromo-β-naphthol, No. 3 (m.p. 191° ; *acetate*, m.p. 210°), described in the 1901 report, which differs from all the other highly brominated naphthols in that it fails to give a nitro-bromo-keto- compound, being converted by nitric acid, at the ordinary temperature, into a tetrabromo-β-naphthaquinone (m.p. 241°).

This tetrabromo-β-naphthaquinone is oxidised by dilute nitric acid to a new dibromophthalic acid, which by exclusion must be the hitherto unknown 3 : 5-*dibromophthalic acid* ; the quinone is therefore 3 : 4 : 6 : 8-*tetrabromo-β-naphthaquinone.*

The parent naphthol, which is derived from 1 : 3 : 6-tribromo not from 1 : 5 : 6-tribromo-β-naphthol, must therefore contain the bromine atoms in positions 1 : 3 : 6 : 8, the series of compounds being related as shown by the following formulæ :—



Tetrabromo-β-naphthol, m.p. 191°. Tetrabromo-β-naphthaquinone, m.p. 241°. 3 : 5-Dibromophthalic acid, m.p. 188° ; *anhydride*, m.p. 155°.

It follows from these results that whilst the product of the further bromination of 1 : 3 : 6-tribromo-β-naphthol is 1 : 3 : 4 : 6-tetra-bromo-β-naphthol small quantities of the 1 : 3 : 6 : 8-tetrabromo- derivative are also formed.

The investigation of the bromo-naphthols has involved incidentally the study of the bromophthalic acids : the discovery of 3 : 4- and 3 : 5-dibromophthalic acids in the course of the work completes the series of dibromo- acids.

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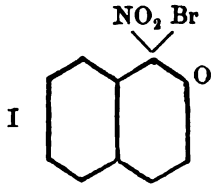
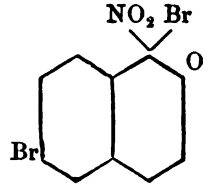
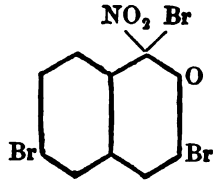
A systematic investigation of the nitro-bromo-keto- compounds formed by the action of nitric acid on the bromo-β-naphthols has led to the important discovery that whereas most of these substances are of normal composition—for instance,



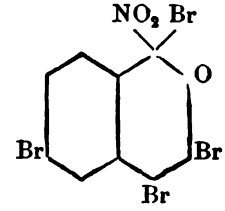
I



II

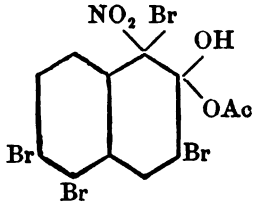


III



IV

others can only be obtained in association either with acetic acid alone or with water of hydration. Thus :



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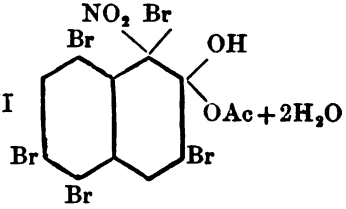
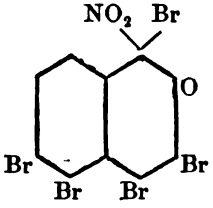


VI

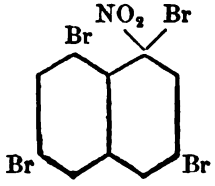
A similar addition of acetic acid takes place in the case of the keto-bromides (*infra*) but apparently not in the case of the keto-chlorides. These, however, as Zincke's researches show, in a few cases combine with alcohol.

Generally speaking, the nitro-bromo-keto- compounds increase in stability as the number of bromine atoms increases, so that, whilst the compound I, for instance, begins to decompose slightly above 0° the compound II is so stable that it may be left exposed during several months in the air at the ordinary temperature without undergoing change. But that structure and not merely the proportion of bromine present in the compound largely determines stability is shown by the fact that, for example, the compounds represented by the formulæ



VII

and VIII



although rich in bromine rapidly decompose at the ordinary temperature.

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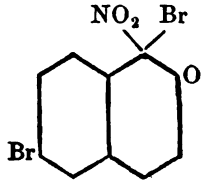
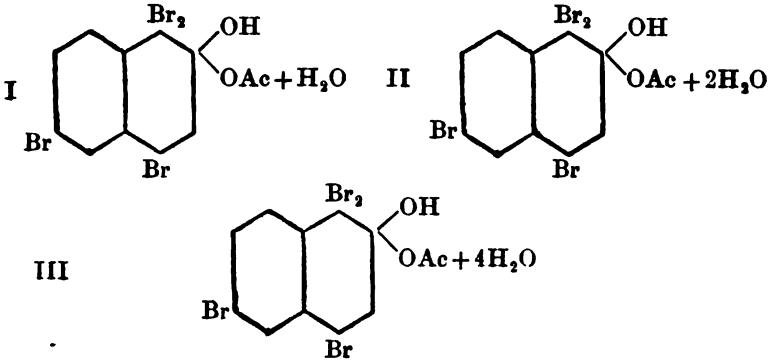
When bromine (1 molecular proportion) is left in contact with the nitro-keto- compound

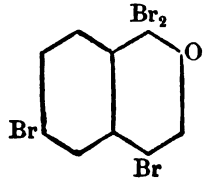


(derived from 1 : 6-dibromo-β-naphthol), suspended in glacial acetic acid and exposed to diffused light, nitrous fumes are slowly evolved and an arborescent mass of needles separates which appears to be the monohydrate (I) of the acetate of a dibromo-naphthalene-keto-bromide



This substance melts at 63–65° ; from the mother liquors large slightly yellow prisms slowly separate which consist of the tetrahydrate III. The dihydrate II is formed only under very special conditions, namely, when a solution of the nitro-bromo-keto- compound from 1-bromo-β-naphthol in acetic acid is acted on by bromine ; it separates very slowly from solution in the form of small nearly colourless needles, melting at 81°.

If any one of these hydrated acetates be gently warmed with benzene a turbid solution is obtained ; if this be dried with the aid of calcium chloride and slowly evaporated it deposits magnificent nearly colourless plates of the simple keto-bromide.



This substance apparently is the first representative of the class of naphthalene keto-bromides corresponding to the keto-chlorides which have been so fully studied by Zincke. When gently warmed, either alone or in the form of one of its hydrated acetates, with glacial acetic acid, it loses bromine and is converted into 4 : 6-dibromo-β-naphthaquinone (m.p. 171°) ; if the warming be continued the liberated bromine acts on this compound, converting it into 3 : 4 : 6-tribromo-β-naphthaquinone

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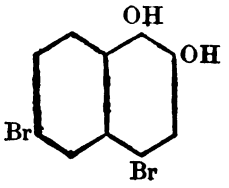
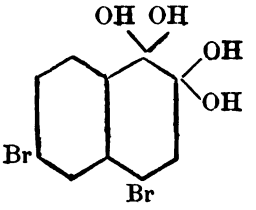
(m.p. 190°). Care is necessary, however, as otherwise the action may go further; a pentabromo-dinaphthyl-diquinone, $C_{20}H_5Br_5O_4$, then separates as a yellow crystalline insoluble powder. This compound is formed according to the equation $2C_{10}H_3Br_3O_2 = HBr + C_{20}H_5Br_5O_4$. A similar case of condensation was mentioned in last year's report.

Unlike the keto-chlorides, the keto-bromides do not give substituted naphthols when reduced either with stannous chloride and chlorhydric acid or with iodhydric acid (d. 1·9); the sole product is 4 : 6-dibromo-1 : 2-dihydroxynaphthalene,

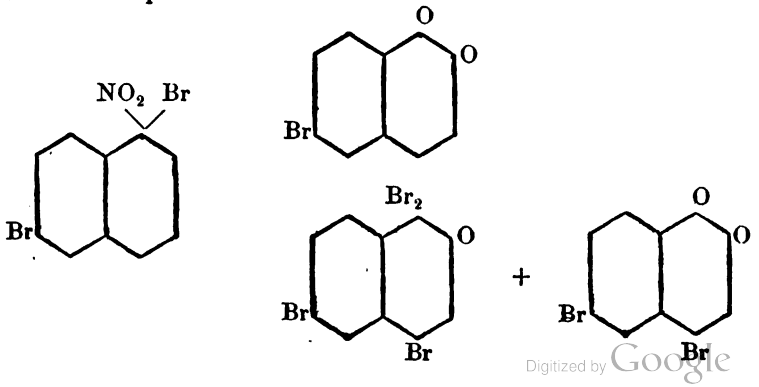


which is also obtained by reducing 4 : 6-dibromo-1 : 2-naphthaquinone. The corresponding diacetate, $C_{10}H_4Br_2(OAc)_2$, crystallises in large prisms, melting at 157°.

The keto-bromide is probably first transformed into



The discovery of 4 : 6-dibromo-2-keto naphthalene-1-dibromide makes it possible to explain the production of 4 : 6-dibromo-1 : 2-naphthaquinone during the decomposition by heat of the nitro-keto- compound of 1 : 6-dibromo-β-naphthol. That the dibromo-quinone could not be formed by a mere bromination of 6-monobromo-β-naphthaquinone initially produced is shown by the fact that this bromination cannot be realised in practice. The real explanation is that the bromine initially split off from the nitro-keto- compound brominates the undecomposed remainder of this substance, first displacing NO_2; a subsequent decomposition produces the 4 : 6-dibromo-quinone.



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Now that the investigation has reached a stage when it is possible to give a complete account of the complex series of processes underlying the formation of the brominated naphthols, it is proposed to submit a considered discussion of the results for publication.

The Study of Hydro-aromatic Substances.—Report of the Committee, consisting of Dr. E. DIVERS (*Chairman*), Dr. A. W. CROSSLEY (*Secretary*), Professor W. H. PERKIN, *and* Drs. M. O. FORSTER *and* LE SUEUR.

Recent Work on Hydro-aromatic Substances. By Dr. A. W. CROSSLEY.

THE following is a summary of the work published on hydro-aromatic compounds since the preparation of the last report.[1]

Petroleum.—When acetylene and hydrogen are passed over reduced nickel, there results a mixture of hydrocarbons having the general properties of petroleum. Sabatier and Senderens[2] therefore put forward the following suggestion as accounting for the production of natural petroleum. In the interior of the earth alkali metals and carbides are found, and these under the influence of water give hydrogen and acetylene, which in contact with finely divided iron, nickel, &c., generate the hydrocarbons of petroleum. This supposition is not considered probable by Aschan,[3] who, from experimental results, is led to conclude that the slow distillation of fossil fat in the earth's interior gives rise mainly to an unsaturated hydrocarbon residue, and to a smaller extent to an unsaturated complex containing carboxyl. Pressure and temperature cause the polymerisation of these residues with production of the naphthenes and naphthene carboxylic acids, which must therefore be regarded as secondary products of the distillation of mineral oil in the earth's interior.

Mabery[4] has described various hydrocarbons, with from thirteen to twenty-eight carbon atoms, isolated from the portion of Pennsylvanian petroleum, boiling above 216°.

Synthetical Hydrocarbons.—Starting with optically active substituted hydroxyhexahydrobenzenes, Zelinsky[5] has propared dimethyl- and methylethylhexahydrobenzenes, both of which hydrocarbons show a slight optical activity.

Harries and Antoni[6] have further investigated the method of preparing substituted dihydrobenzenes by distilling the phosphates of certain diamines. The dihydrobenzene prepared from dihydroresorcin by this method adds on four atoms of bromine to give the solid tetrabromide melting at 184°; whilst starting with dihydroresorcin, and submitting it to the method of Crossley and Le Sueur,[7] the resulting dihydrobenzene absorbs only two atoms of bromine, forming a dibromide which melts at 104°·5, and decomposes with evolution of hydrogen bromide at 170°.[8]

The series of substituted ketotetrahydrobenzenes described by Knoevenagel[9] provides a starting-point for the preparation of substituted

[1] *Reports*, 1902, 120.
[2] *Compt. Rend.*, 1902, **134**, 1185.
[3] *Annalen*, 1902, **324**, 1.
[4] *Amer. Chem. J.*, 1902, **28**, 165.
[5] *Ber.*, 1902, **35**, 2677.
[6] *Annalen*, 1903, **328**, 88.
[7] *J.C.S.*, 1902, **81**, 822.
[8] Crossley and Haas, *J.C.S.*, 1903, **83**, 494.
[9] *Annalen*, 1894, **281**, 225.

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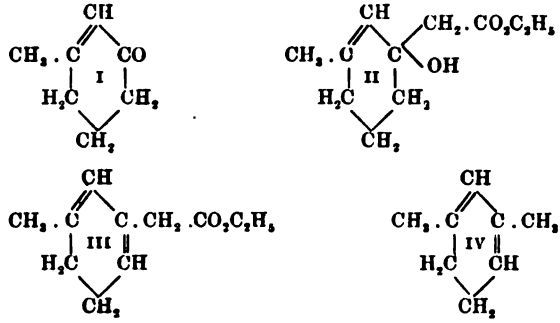
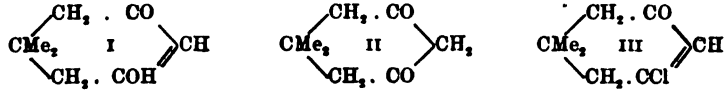
dihydrobenzenes and dihydrobenzenecarboxylic acids,[1] as illustrated by the following example :—



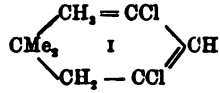
Methylketotetrahydrobenzene (I) when treated with zinc and ethyl-bromacetate gives rise to an oxy-ester (II), which cannot be isolated, as it so readily loses water, giving an unsaturated ester (III). This latter, on saponification, yields the corresponding dihydro-meta-tolylacetic acid, which when heated under pressure evolves carbon dioxide, with production of dihydro-meta-xylene (IV).

Hydroxy- derivatives. — 1 : 2-dihydroxyhexahydrobenzene.[2] Methylcyclohexanose.[3]

Dihydroresorcins.—The action of phosphorus haloids on dihydroresorcins[4] confirms the opinion that these substances behave in general as if they possessed the ketoenol (I), and not the diketonic structure (II).



Thus dimethyldihydroresorcin gives with phosphorus trichloride, 5-chloro-3-keto-1 : 1-dimethyl-Δ^4-tetrahydrobenzene (III), and with phosphorus tribromide the corresponding bromo- derivative ; whereas phosphorus pentachloride produces 3 : 5-dichloro-1 : 1-dimethyl-$\Delta^{2:4}$-dihydrobenzene



Phosphorus pentabromide behaves as a mixture of bromine and phosphorus tribromide, and gives rise to a complicated mixture of bodies, varying greatly according to the conditions of experiment. Among the substances isolated were bromodimethyldihydroresorcin, tribromoketodimethyltetrahydrobenzene, and several bromoxylenols, which latter are, however, not primary products of the reaction.

Acids.—A method for the synthetical production of dihydrobenzenecarboxylic acids, with ketotetrahydrobenzenes as starting-point, has already been alluded to. Hexahydro-aromatic acids and polymethylenecarboxylic acids in general can be prepared[5] from the iodine or bromine

[1] Wallach, *Annalen*, 1902, **323**, 135. [2] Brunel, *Compt. Rend.*, 1903, **136**, 383.
[3] Zelinsky and Roschdestwensky, *Ber.*, 1902, **35**, 2695.
[4] Crossley and Le Sueur, *J.C.S.*, 1903, **83**, 110 ; Crossley and Haas, *ibid.* 494.
[5] Zelinsky, *Ber.*, 1902, **35**, 2687.

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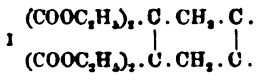
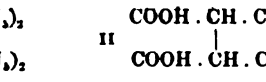
derivatives of hexahydrobenzene and its homologues. These substances react readily with magnesium to form organo-metallic compounds, which with carbon dioxide yield the magnesium salts of the corresponding carboxylic acids. Iodohexahydrobenzene is under these conditions transformed into hexahydrobenzoic acid.

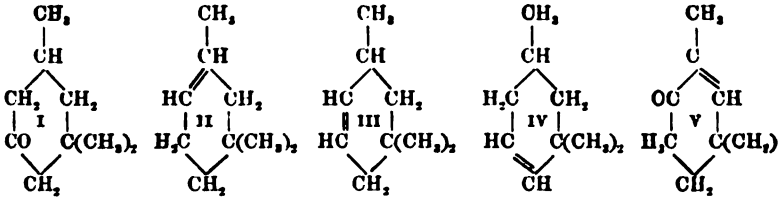
When ethyl dibromopropanetetracarboxylate[1] is condensed with ethyl-disodiopropanetetracarboxylate it gives rise to ethyl hexahydrobenzene-octocarboxylate (I).





On hydrolysis this ester yields the corresponding octocarboxylic acid, which loses carbon dioxide on heating, with formation of a mixture of *trans*-hexahydrobenzenetetracarboxylic acid (II) (hexahydropyromellitic acid), and the double anhydride of the *cis* modification of the same acid.

Transformation of Ketones.—Cyclic alcohols when dehydrated often form unsaturated hydrocarbons isomeric with those that would be expected from the constitution of the alcohol, thus providing the initial step in the transformation of a ketonic oxygen from one carbon atom to another.[2] For example, 1 : 3 : 3-trimethyl-5-ketohexahydrobenzene (I) (dihydroisophoron) on reduction



gives the corresponding alcohol, which on dehydration yields a trimethyltetrahydrobenzene identical in every respect with geraniolen, and therefore possessing formula II ; though a hydrocarbon with either formula III or IV would naturally have been expected to result. On treating the nitrosate of this trimethyltetrahydrobenzene with sodium methylate it yields an oxime identical with the oxime of 1 : 3 : 3-trimethyl-6-ketotetrahydrobenzene (V). The ketone regenerated from this oxime can by the usual reactions be converted into the corresponding saturated ketone 1 : 3 : 3-trimethyl-6-ketohexahydrobenzene, thus completing the transformation of the ketonic group from its original position 5 to position 6.

Aromatic from Hydro-aromatic Substances.—Phosphorus pentachloride in excess converts 3 : 5-dichlorodihydrobenzene into metadichlorobenzene,[3] and dichlorodimethyldihydrobenzene into dichloro-ortho-xylene.[4] In the former case bromine reacts in the same way as phosphorus pentachloride, but not so in the latter case, where there is obtained a series of chlorobromoxylenes.

[1] Gregory and Perkin, *J.C.S.*, 1903, **83**, 780.
[2] Wallach, *Annalen*, 1902, **324**, 112.
[3] Crossley and Haas, *J.C.S.*, 1903, **83**, 502.
[4] Crossley and Le Sueur, *J.C.S.*, 1902, **81**, 1536.

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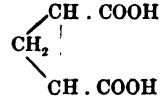
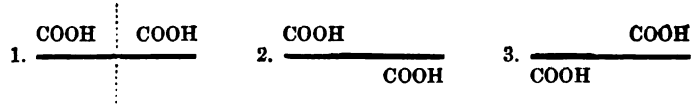
Stereochemistry.—A graphic method of demonstrating the number of different stereoisomeric forms in which a substance can exist, has been brought forward by Aschan,[1] as being preferable to the use of models. It is shown in detail that the possibilities of isomerism in ring-systems are more truly seen when the symmetry of the molecule is alone considered; and further, it is demonstrated on these lines that optical activity becomes possible in certain ring-systems in the absence of an asymmetric carbon atom.

If one imagines the plane of a carbon ring of an alicyclic compound as standing vertical to the plane of the paper, it can, provided the ring atoms lie in one plane, be represented by a straight line on the paper. The substituents (omitting hydrogen atoms and unsubstituted methylene groups) are then written, according as to whether they lie on the upper or lower half of the ring, above or below the projected line. Only such forms are identical as can be superimposed either directly or after turning through 180° in the plane of the paper.

The simplest example is afforded by trimethylenedicarboxylic acid,



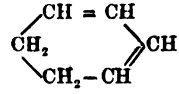
which can exist in the three following forms :—



A plane of symmetry can be drawn through form 1, which is not possible with 2 and 3, these being mirror images of one another. Aschan defines as optically isomeric only those substances which are mirror images of one another, whilst the term geometrical isomerism applies to all those stereoisomeric forms, active or inactive, which show a dissimilarity in all their physical properties.

On Dihydrobenzenes and on Aromatic Compounds derived from Hydro-aromatic Substances. *By* Dr. A. W. Crossley.

Dihydrobenzene.—It has been shown that the dihydrobenzene obtained from dihydroresorcin [2] has the formula



that is, the double bonds are in the 1 : 3 position. Up to the present time it has not been found possible to prepare the hydrocarbon in a pure condition, as it is contaminated with tetrahydrobenzene; but further experiments are being conducted in the hope of obtaining the pure substance by this method.

A second means of producing this same dihydrobenzene seemed to consist in the removal of two molecules of hydrogen bromide from

[1] *Ber.*, 1902, 35, 3389.

[2] *J.C.S.*, 1903, 83, 494.

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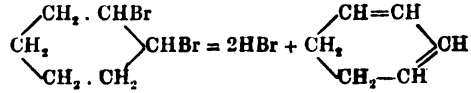
dibromotetrahydrobenzene, there being only one possible way in which the hydrogen bromide could be eliminated.

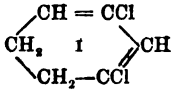


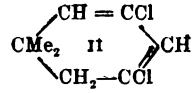
This reaction has been tried by Baeyer [1] and Fortey.[2] The latter states that when dibromotetrahydrobenzene is treated with quinoline, dihydrobenzene is formed; but no details of any sort are given. It is therefore to be presumed the author concluded that the dihydrobenzene so formed was the one giving a tetrabromide melting at 184°.

Preliminary experiments have conclusively proved that such is not the case, for the hydrocarbon so obtained gives no trace of the tetrabromide melting at 184°, but only the dibromide melting at 104°·5, thus proving it to be $\Delta^{1:3}$-dihydrobenzene.

Final experiments, with larger quantities of material are now being carried out.

Aromatic Compounds derived from Hydro-aromatic Substances.—When dichloro-dihydrobenzene [3] (I) and dichloro-dimethyldihydrobenzene [4] (II)





are treated with excess of phosphorus pentachloride, they are converted respectively into metadichlorobenzene and 3 : 5-dichloro-ortho-xylene. Bromine produces the same change with dichlorodihydrobenzene,[5] two atoms of bromine being first added on and then eliminated on distillation as hydrogen bromide.

It was thought that the reaction would be the same with bromine and dichloro-dimethyldihydrobenzene, a supposition which proves to be incorrect; for though the aromatic substances obtained are always substituted ortho-xylenes, they consist for the most part of dichlorobromoxylenes, of which both the possible forms with the chlorine atoms in the 3 : 5 position have been isolated—namely, 3 : 5-dichloro-4-bromo-ortho-xylene and 3 : 5-dichloro-6-bromo-ortho-xylene. The work is not in a sufficiently advanced state to warrant the publication of further details.

Edenvale Caves, co. Clare.—Report of the Committee, consisting of Dr. R. F. Scharff (*Chairman*), Mr. R. Lloyd Praeger (*Secretary*), Mr. G. Coffey, Professor G. A. J. Cole, Professor D. J. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, *and* Mr. R. J. Ussher, *appointed to explore Irish Caves.* (*Drawn up by* Mr. R. J. Ussher).

In April 1902 Dr. Scharff and Mr. R. J. Ussher visited some caves in the co. Clare, and decided to explore two at Edenvale, near Ennis, which adjoined each other and proved to be connected.

[1] *Annalen*, 1894, **278**.
[2] *J.C.S.*, 1898, **73**, 948.
[3] *J.C.S.*, 1903, **83**, 502.
[4] *J.C.S.*, 1902, **81**, 1536.
[5] *J.C.S.*, 1903, **83**, 502.

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Another system of connected caves was subsequently explored there, and both groups of cavities were found to be prolific in remains of animals now extinct in Ireland, and in human relics of different periods.

Edenvale House stands on a ridge of Carboniferous Limestone, which forms the western side of a deeply cleft anticlinal; in the chasm thus formed lies a lake of relatively great depth, which is surrounded by a steep declivity on all sides but one.

The first two cavities referred to, which have been named the Alice and the Gwendoline caves, open in a low escarpment on the western side of the Edenvale ridge. Their aspect is southerly.

The Alice cave, after running a straight course for 80 feet, was found to terminate in an upward opening that had been filled in with earth and stones, and contained material resembling that found in kitchen middens. At 40 feet from the mouth of this cave a gallery branched off, and connected it with the Gwendoline cave on a lower level.

At 15 feet from the mouth of the Alice cave a projection in the rocky wall was worn smooth, as if by the constant rubbing of creatures which had passed in and out.

In most parts of these caves two strata were distinguishable:—

1st and upper. Brown earth, occasionally containing calcareous tufa. In this stratum was found much charcoal, bones of man and domestic animals in a fragmentary state, and also objects of human art of various descriptions—a bone pin or awl, an amber bead, a bracelet of bronze, and another of gold.

2nd. A lower stratum composed of clay, generally of a yellow-ochre tint, but sometimes purplish.

Bones and teeth of reindeer and bear were found chiefly in the latter stratum, and the ursine remains indicated that they belonged to individuals of great size.

Having removed the fossiliferous deposits of the above caves, operations were commenced at the orifice of the second group, opening in the cliff-face under Edenvale House overlooking the lake.

This cave runs 50 feet into the rock, but is traversed by a series of galleries, some of which are wide and confluent. One of these galleries was excavated for a distance of 60 feet, and it was found to be crossed by another cave that led out to the cliff, but whose orifice is blocked.

This system of caves is so extensive and complex that we have named it the Catacombs. It has proved still more fruitful than the former caves in relics of man and of extinct animals. Human bones were frequent, and in one place an assemblage of these included a cranium not far from which there were two stout iron knife-blades. A strap of bronze bearing a buckle was found elsewhere, ornamented with an interlaced pattern in silver plating. In other parts of the Catacombs were chipped flint scrapers, a bone piercer, a tusk of a large boar pierced as if to form an amulet, and a marine shell similarly pierced.

Several marine shells occurred, although the sea is many miles away from the site; also much charcoal and bones of horse, ox, pig, sheep or goat and dog.

Bones and teeth of bear and reindeer were of daily occurrence in excavating the deposits, and in a few cases we obtained pieces of the bones and of the antlers of the great Irish deer (Irish Elk).

The large collections of human and animal remains found in the Eden-

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vale caves are in course of examination, and the further exploration of the Catacombs is in progress, there being reason to believe that the unexplored portions considerably exceed those that have been examined.

Life-zones in the British Carboniferous Rocks.—Report of the Committee, consisting of Dr. J. E. MARR (*Chairman*), Dr. WHEELTON HIND (*Secretary*), Dr. F. A. BATHER, Mr. G. C. CRICK, Dr. A. H. FOORD, Mr. H. FOX, Professor E. J. GARWOOD, Dr. G. J. HINDE, Professor P. F. KENDALL, Mr. R. KIDSTON, Mr. G. W. LAMPLUGH, Professor G. A. LEBOUR, Mr. B. N. PEACH, Mr. A. STRAHAN, *and* Dr. H. WOODWARD. (*Drawn up by the Secretary.*)

THE Secretary regrets that he has received no reports from members of the Committee, and that the small sum of money voted last year, 5*l.*, has not permitted work to be carried on on the usual scale.

In the spring, a chart of the chief fossil shells found at various horizons of the North Staffordshire coalfield was published by the Institute of Mining and Mechanical Engineers.

This chart was drawn up by Mr. J. T. Stobbs, F.G.S., and Dr. W. Hind, F.G.S., and shows a section of the North Staffordshire coalfield, with the marine beds at present known; each bed in the section has opposite to it the shells found in it, or a reference by a number to a shell figured as being found in other beds. This chart is an amplification of a section of North Staffordshire coalfields and on which the horizons at which fossil shells occur, drawn up by Dr. W. Hind and published in his monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*. The authors contend that many of the important seams of the North Staffordshire coalfield can be easily recognised by the mollusca found in connection with them, and that the marine bands form absolutely certain indices of horizons.

Collecting has been carried on by Mr. J. T. Stobbs, F.G.S., in Wensleydale and in Teesdale.

The Secretary determined to examine the bed of Limestone mapped in Quarter Sheet 102 S.E., which occurred intercalated in the Millstone Grit beds. Mr. W. Gibson had called attention to this bed, thinking it possible that the Pendleside fauna might be found there, but such is not the case.

The carefully drawn up reports and sections by Mr. Stobbs speak for themselves. The fossils are unfortunately not worth preserving, but the Secretary has been able to identify the great majority, and his identifications are included in the lists in Mr. Stobbs's report.

The district comprising Mickleton and Underthwaite Moors lies between the River Lime and the River Balder (both of which are southern tributaries of the River Tees), and is known as part of the area whence the water-supply of Stockton and Middlesbrough is obtained. At the present time three shafts and a tunnel are in progress of driving, the positions of which are shown in fig. 1. The opportunity was taken of inspecting the débris brought to the surface as a consequence of these works.

The rocks occupying this area belong to the upper portion of the Yoredale series, and consist mainly of finely laminated black shales. The freestones are hard and approximate to the 'gannister' type. The sections afforded by the streams marked (A) were also examined (see fig. 2). The whole series of beds points to a gradual termination of those

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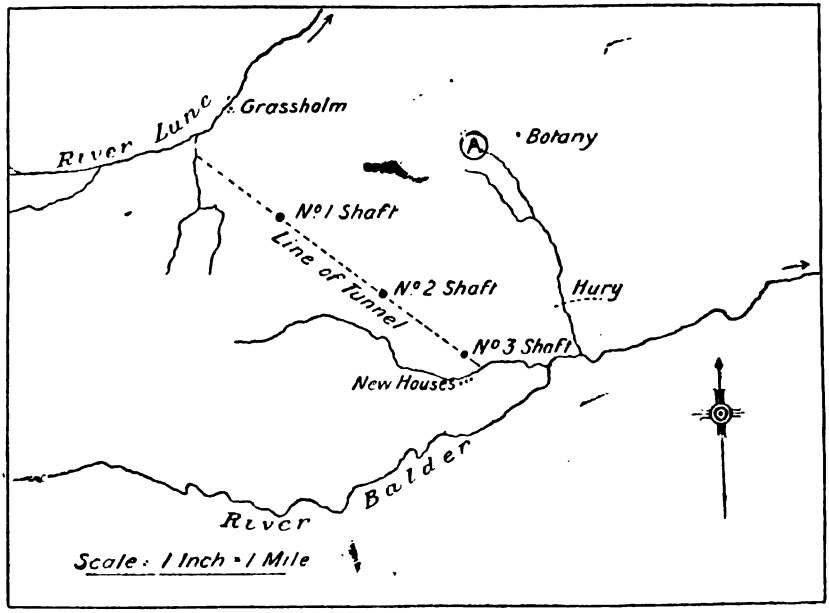
recurrences of clear deep-sea conditions during which the Yoredale Limestones were deposited. In this district the Crystalline Limestones are

FIG. 1.



very thin, whilst the thicker ones are shallow-sea deposits, as proved by their detrital character.

No. 2 Shaft (fig. 1) at Bullhill Sike passed through the following beds :—

	ft.	in.	
Black shales . .	40	0	Fossiliferous bullions.
Hard gannister . .	3	0	*Edmondia sulcata, Protoschizodus axiniformis.*

From the black shales the following fossils were collected :—

Archæocidaris sp.
Chonetes Lagnessiana.
Discina nitida.
Lingula mytiloides.
Orthis Michelini.
Orthotetes crenistria.
Productus longispinus.
Spirifera lineatus.
Ctenodonta sp.
Syncyclonema sp.
Bellerophon sp.
Raphistoma sp.
Trilobite.

The mouth of the tunnel at No. 3 Shaft is driven in dark shale containing a 1-inch band of Limestone, from which were obtained the following :—

Camarophoria crumena.
Orthotetes crenistria.
Productus scabriculus.
Rhynchonella pleurodon.
Spirifera trigonalis?
Phillipsia sp.
Reed-like plant-remains.

In the shale itself *Aviculopecten dissimilis* was obtained.

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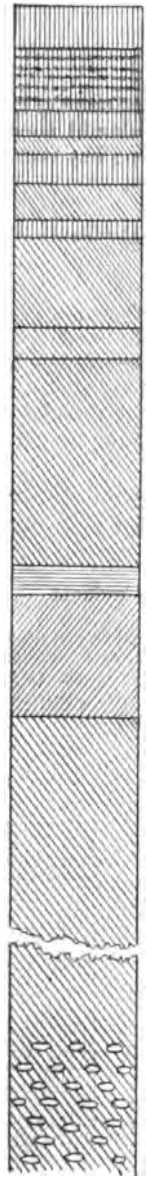
The succession of beds in the stream (A) (fig. 1), which flows into the reservoir near Hury, is shown in fig. 2.

FIG. 2.



	ft.	in.	
1. Limestone	4	0	
2. Limestone in thin nodular beds	6	0	
3. Crystalline limestone	2	9	
4. Blue shale	1	6	
5. Limestone	2	9	(crinoidal)
6. Finely laminated blue shale	4	0	
7. Limestone		10	
8. Fissile shales	9	0	
9. Shales with calcareous nodules	3	0	
10. Dark fissile shale	22	0	
11. Grey fireclay	2	9	
12. Freestone	18	0	
13. Dark micaceous shales, with bullions at base	180	0	(estimated)

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Beds (1) and (2) are detrital limestones, from which the following list was collected :—

Cyathophyllum sp., abundant near top.
Archæocidaris sp.
Fenestella sp., abundant in layers near top.
Athyris ambigua.
Chonetes Buchiana.
Productus aculeatus.
„ *plicatilis.*
Productus semireticulatus (full sized).
Productus undatus.
Spirifrina octoplicata.
Strophomena analoga.
Aviculopecten dissimilis.
„ sp.
Edmondia sulcata.

The thin crystalline Limestone (7) weathers reddish-yellow, and from its fossiliferous character it should constitute a good horizon for stratigraphical work. The following list was obtained :—

Crinoid.
Orthotetes crenistria.
Productus punctatus (abundant).
„ *scabriculus.*
„ *sinuatus.*
Rhynchonella pleurodon.
Edmondia sp.
Parallelodon sp.
Bellerophon Urei.
Macrocheilus sp.

No fossils were found in the shales (8), (9), and (10).

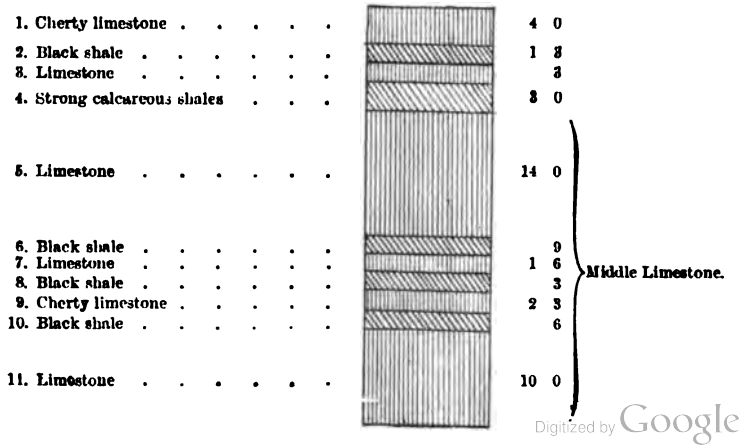
The grey fireclay (11) contained a fair abundance of rootlets, and in the Freestone (12) *Stigmaria ficoides* was found. No fossils were seen either in the thick deposit of shale (13) or its contained bullions.

In Wensleydale the typical Yoredale Rocks were examined, and fossils were collected from the uninterrupted sections afforded by Mill Gill, represented in fig. 3.

The following is a statement of the fossils found in the various beds :—

1. Cherty Limestone. *Productus giganteus* (common).
2. Black shales. *Productus giganteus.*
4. Strong calcareous shales.
Productus giganteus (abundant).
„ *longispinus.*
Productus semireticulatus.
Spirifera sp. (common).
9. Cherty Limestone. *Productus giganteus.*
10. Black shale. *Productus semireticulatus.*
11. Limestone, the upper part is cherty; at the base is a layer crowded with *Lithostrotion*, *Syringopora*, and *Cyathophyllum.*
14. Black shale. *Spirorbis helicteres?*; and fragments of plant-remains in the roof-layer of (15) coal.
16. Fireclay. Rootlets

FIG. 3.


ft. in.
1. Cherty limestone 4 0
2. Black shale 1 3
3. Limestone 3
4. Strong calcareous shales . . . 3 0
5. Limestone 14 0
6. Black shale 9
7. Limestone 1 6
8. Black shale 3
9. Cherty limestone 2 3
10. Black shale 6
11. Limestone 10 0
Middle Limestone.

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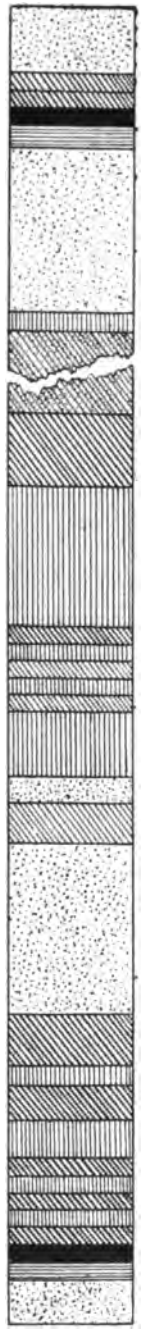

12. Sandstone	8 0	
13. Arenaceous shale	2 0	
14. Black shale	4	
15. Coal	1½	
16. Fireclay	2 6	
17. Sandstone	18 0 (estimated)	Hawes Flags.
18. Limestone	1 9	
19. Sandstone and arenaceous shales	52 0 (estimated)	
20. Black shales	8 0	
21. Limestone (six beds)	15 3	
22. Black shale	10	Simonside Limestone.
23. Limestone	1 0	
24. Shale	2	
25. Limestone	6	
26. Shale	3	
27. Limestone	7 0	
28. Sandstone	2 0	
29. Arenaceous shales	4 6	
30. Sandstone	18 0	
31. Black shale with nodules	6 6	
32. Limestone	4	
33. Soft black shales	3 6	
34. Limestone	4 9	
35. Black shales	3	
36. Limestone	3	
37. Black shale	1 0	
38. Nodular limestone	6	
39. Black shale	6	
40. Coal	2	
41. Fireclay	2 0	
42. Sandstone	6 0	

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43. Shale	4	
44. Sandstone	10	
45. Black shale	1 6	
46. Nodular limestone	3	
47. Black shale	5	
48. Limestone	9 0	Hardraw Scar Limestone.
49. Black shale	5	
50. Limestone	32 0 (estimated)	
51. Sandstone	35 0 (estimated)	
52. Black shales with nodules	15 0	
53. Nodular limestone	3	
54. Shales	5 0	
P.B.		
55. Limestone		Great Scar Limestone.

Scale : 20 feet per inch.

20. Black shales.

Fenestella sp.
Orthis Michelini.
Productus semireticulatus.
Amusium concentricum.
Aviculopecten clathratus.
Pseudamusium anisotus.
Euomphalus carbonarius.
Rhapistoma junior.
Phillipsia sp.

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32. Limestone.

Allorisma sulcata (common). *Naticopsis.*

34. Limestone. *Productus giganteus* (in lower portion).
41. Fireclay (upper part gannister-like). Rootlets.
46. Nodular limestone. *Naticopsis* sp.
48. Limestone (Hardraw Scar). Upper portion weathers red.

Productus semireticulatus, var. *costatus.* *Lithostrotion.*

49. Black shale.

Productus giganteus. *Syncyclonema Sowerbii.*

51. Sandstone. Upper portion thickly bedded, lower portion flaggy.
52. Black shale with nodules.

Fenestella sp.
Athyris ambigua.
Chonetes Buchiana.
„ *papilionacea.*
Dielasma hastata.
Orthis Michelini.
„ *resupinata.*
Orthotetes crenistria.
Productus aculeatus.
„ *costatus.*
„ *giganteus?*
„ *longispinus.*
„ *scabriculus.*
„ *semireticulatus.*
„ *undatus.*
Rhynchonella pleurodon.
Rhynchonella trilatera.
Spirifera lineata.
„ sp.
Spiriferina cristata.
Aviculopecten clathratus.
Ctenodonta lævirostris.
Edmondia McCoyi.
„ *unioniformis* (young).
Leiopteria squamosa.
Nucula luciniformis.
Pseudamusium ellipticum.
Scaldia Benediana.
Syncyclonema Sowerbii.
Macrocheilina acuta?
Stroboceras sulcatus.
Phillipsia sp.

53. Nodular Limestone. *Macrocheilina* sp.
54. Shales.

Orthis Michelini.
Productus semireticulatus.
Posidonomya Becheri (abundant in layer marked P. B., fig. 3).

55. Great Scar Limestone. *Productus giganteus.*

From the underset Limestone above Mill Gill, the following were obtained :—

Productus giganteus.
„ *latissimus.*
„ *punctatus.*
Productus semireticulatus.
Spirifer ovalis.
Athyris sp.

Remarks : It will be observed that *Productus giganteus* ranges from the bottom to the top of the section and is met with both in the Limestones and the shales.

Posidonomya Becheri is very abundant in a layer of shale about 9 inches above the Great Scar Limestone, and may be useful in describing that limestone in other districts.

The occurrence of *Spirorbis helicteres* so low down on the carboniferous system is especially noteworthy. It is fairly abundant in the roof-shale of (15) Coal, with which it is associated in the same way as with the Coal-seams of the true Coal-measures.

The two thin coals (15) and (40) may be used as indexes to the Middle Limestone and the Hardraw Scar Limestone respectively, No. 15

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Coal being 10 feet 4 inches *below* the Middle Limestone, whilst No. 40 Coal is 11 feet 4 inches *above* the Hardraw Scar Limestone.

In conclusion the Committee would ask for a larger grant than 5*l*., which only covered railway fares and actual out-of-pocket expenses, and would point out that the reports have always justified the grant.

Miss Jessie Barker sends me the following list of fossils which she collected from a shale top at Newbrough. Professor Lebour informed her that the horizon of that shale was somewhat doubtful owing to faulting, but 'at any rate the shale is very near one of the limestones next beneath the 4 fathom Limestone, and called the 3 yard, 5 yard, and Scar Limestone respectively.'

1. *Monticulipora tumida.*
2. *Archæocidaris Urei.*
3. *Poteriocrinus fusiformis.*
4. *Serpulites carbonarius.*
5. *Ostracod*, possibly *Carbonia.*
6. *Fenestella* sp.
7. *Rhabdomeson gracile.*
8. *Polypora* sp.?
9. *Polyzoa* genus?
10. *Lingula mytiloides.*
11. *Crania?*
12. *Productus semireticulatus.*
13. „ *striatus.*
14. „ *punctatus?*
15. „ *giganteus.*
16. *Productus longispinus.*
17. *Spirifera convoluta.*
18. „ *laminosa.*
19. *Athyris ambigua.*
20. *Dielasma hastata.*
21. *Chonetes Laguessiana.*
22. *Rhynchonella* prob. *triangularis.*
23. *Orthotetes crenistria.*
24. *Myalina pernoides.*
25. *Actinopteria persulcata.*
26. *Pteronites angustatus.*
27. *Bellerophon Urei.*
28. *Porcellio puzio.*
29. *Strepsodus sauroides.*
30. *Labyrinthodon.*

1, 4, 6, 7, 8, 9, and 18 determined by Dr. G. J. H.; 3, Mr. F. A. B., also 2, I think, but it is quite unmistakable; 30, Dr. H. Woodward; the remainder by Dr. W. Hind.

The Movements of Underground Waters of North-west Yorkshire.—*Fourth Report of the Committee, consisting of* Professor W. W. Watts (*Chairman*), Mr. A. R. Dwerryhouse (*Secretary*), Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. George Bray, Rev. W. Lower Carter, Mr. T. Fairley, Mr. Percy F. Kendall, *and* Mr. J. E. Marr. (*Drawn up by the Secretary.*)

[Plates II. and III.]

The Committee is carrying out the work in conjunction with a committee of the Yorkshire Geological and Polytechnic Society.

On April 4 the members of the joint committee resumed the work of tracing the underground waters of Ingleboro', described in previous reports.

On that day half a pound of fluorescein was put into the sink at the Washfold (P 52) on Bent Hill Rig, Park Fell, at 2.15 p.m. This had almost disappeared at 6.15 p.m., when a second half-pound was introduced, this being arranged so as to flow in slowly and keep up the supply for a considerable time. The stream was still coloured on April 5 at 1.30 p.m., when the remainder of the charge was sent down in a flush. The stream was slowly dwindling on the 5th, it having been in flood on the previous day.

All the springs in the neighbourhood were carefully watched for several

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days, but as yet no result has been observed. This sink will be again tested during the current year.

While waiting for the result of the above experiment the survey of the underground passages in the neighbourhood of Alum Pot was continued.

Previous experiments tried at the stream sinking at P 14 on Farrar's Allotment having been without result, 2 lb. of fluorescein were put in there at 7 P.M. on June 26.

A look-out was kept at all the springs from Austwick Beck Head to Turn Dub for a period of ten days, and also by residents in the neighbourhood up to the time of the next visit of the Committee, but without result.

On the day following the introduction of the test there was a very heavy flood, which may account for the non-success of the experiment. This stream will be tried again as soon as favourable conditions occur.

Streams near Ribblehead Station.

S 102 is a small spring issuing from the grit beds of the Yoredale Series, above Keld Bank, on Park Fell. The stream from this spring sinks at P 73, about half a mile south-west of the station, at a height of 1,240 feet above the sea.

A quarter of a pound of fluorescein was introduced at P 73 at noon on June 29, and was seen at S 103 at 3.30 P.M. on the same day. It again sank at P 74, and reappeared at S 104 at 3.35.

About 30 yards below S 104 the stream has been partially diverted to P 76, but a portion flows down the natural channel to P 75.

By turning the whole stream alternately down P 75 and P 76 it was possible to trace both lines of flow.

First the stream was turned down the normal channel to P 75, and the fluorescein was seen at P 77 at 4.35 P.M., where it again sank, and was seen half an hour later in P 78.

Secondly, the flow having been diverted into the artificial channel to P 76, the colour was seen in a trough at Brock Holes, the flow being partly by a natural channel parallel to the main joints in the limestone, and partly by a pipe to supply the trough.

Fluorescein was next put into P 67, and was traced by S 95, P 68, S 69, P 69, and S 97, to P 70, where it finally sank.

The fluorescein from all the above streams emerged at S 99, below the Station Hotel at Ribblehead, and subsequently at Batty Wife Hole, S 100. It then flowed overground to P 72, where it again sank, to come to light at S 101, near the bank of the Ribble below Gauber Farm, and so into the river.

The spring at S 101 is similar in appearance to Turn Dub, described in the last report of the Committee, but is much smaller.

In wet weather the excess of water from Batty Wife Hole flows over the surface, by way of Batty Wife Beck, into the Ribble, which it then joins some 100 yards further up-stream than the water which goes underground.

Streams near Colt Park Farm.

The streams sinking at P 62, P 63, and P 64, near High Barn, were found to unite in the spring at S 89 and to flow overground to Colt Park Farm, where the water sank, to reappear at S 90, whence it flowed overground for a few yards and again sank. This water was again seen in the spring S 93, in Salt Lake Quarry, where it forms a waterfall visible from the railway. It then crosses beneath the railway and sinks in a

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mass of glacial gravel at P 65, below which point we were unable to trace its course.

The fluorescein from the flows just described having been allowed to pass off, the streams sinking at P 48 and P 49 near Bent Hill Rig Barn were next tested. These were found to unite and to flow along a master joint in the limestone *via* P 59 and P 60, and then to turn down a cross-joint to S 88, on Ashes Shaw Pasture Rocks. From S 88, after an overground journey of about ten yards, the water sinks at P 61, and again resumes the direction of the master joints, running parallel to the hillside to Rake Spring, S 91.

The stream from Rake Spring flows overground past the south end of Salt Lake Quarry, beneath the railway, and through Ashes Gill Plantation to P 66, on Ashes Eller Bank, where it sinks in glacial drift near the river.

Sinks on Fell Close.

There are three streams flowing over Fell Close, viz. Keld Bank Spring East, sinking at P 79, Fairweather Spring East; sinking at P 80, and Fairweather Spring West at P 81.

These three streams were found to unite, and to issue at Eller Keld Spring, S 106, whence the water flows into the bed of Winterscale Beck, otherwise known as Haws Gill, where it again sinks to join the main drainage of Chapel-le-Dale, which will be described later.

Proceeding southwards, the next stream is Keld Bank Spring West, which sinks on Scar Close Moss, at P 82.

Fluorescein was put into P 82 at 12 noon on July 4, and was seen at S 105 and P 83 at 5 P.M. on the same day, and on the following day at P 84, and at Eller Keld Spring, S 106.

The group of small streams sinking at P 93, on Fenwick Lot, are almost dry in summer, and have not yet been tested. They probably fall into Douk Cave, P 95, but this will be determined in due course.

The Washfold on Souther Scales Fell.

The group of streams sinking at the Washfold, P 94 and 96, on Souther Scales Fell, were tested on June 30, at 2.30 P.M., and the fluorescein was seen in Douk Cave, P 95, at 3.50 the same afternoon, having traversed a well-marked joint running N. 10° W., *via* the pothole known as Little Douk Cave.

In Douk Cave the water again sinks, and the green colour was observed in Chapel Beck, in the pool below Gods Bridge, at 1 P.M. on July 3, and was much stronger at 2.30 P.M.

The stream was low at the time, and there was little water above Gods Bridge. Weathercote Cave, P 88, and Hurtle Pot, P 90, were carefully watched from June 30 to July 3, but no trace of fluorescein was to be seen in either. The conclusion arrived at was, therefore, that the water from Douk Cave joins Chapel Beck on some part of its underground journey between Hurtle Pot and Gods Bridge.

The main joint at Douk Cave runs N. 65 W., and this, if continued, would strike the main stream in the neighbourhood of the Vicarage, which agrees very well with the conclusion mentioned above.

The small streams sinking at P 97, P 98, and P 99, still remain to be tested.

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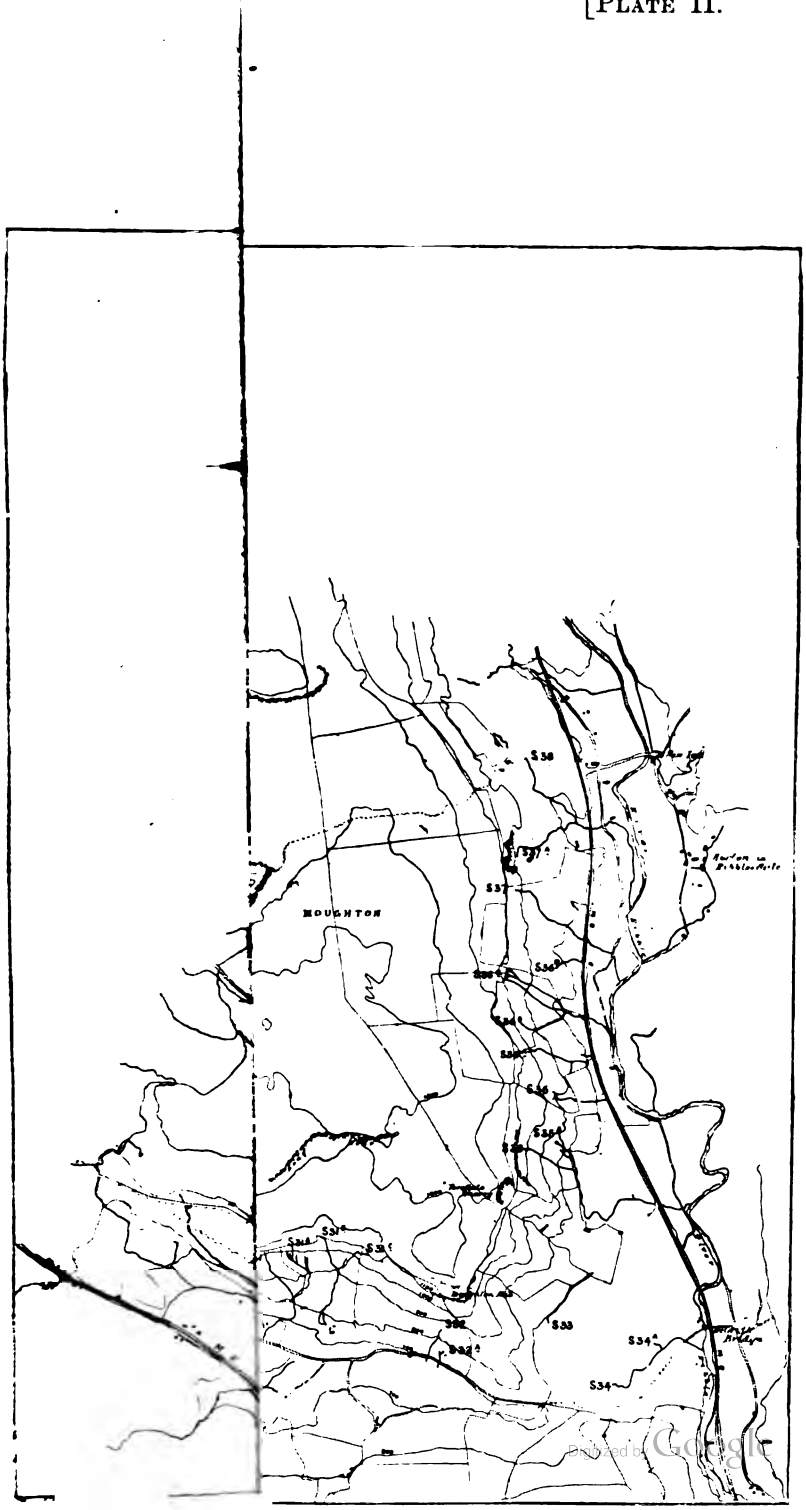

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Mere Gill Hole.

Mere Gill rises on the upper slopes of Ingleboro', and flows down the hollow known as Humphry Bottom, and sinks in a large open joint running N. 50 W. at Mere Gill Hole, on Mere Gill Platt.

Mere Gill was charged with fluorescein at 1 P.M. on July 4, and the colour was observed on the following morning in the spring S 111, on the left bank of Chapel Beck, immediately above Gods Bridge, and almost in the direct line of the master joint at Mere Gill Hole. From S 111 the water passed under Gods Bridge by way of P 91, and reappeared below the bridge at S 112.

The small streams sinking at P 101 and 102, on Black Shiver Moss, to the south-west of Mere Gill Hole, have not as yet been tested.

Passing along the hillside in a south-westerly direction, the next stream of importance is that at Crina Bottom, the course of which has been described in a previous report.

Long Kin West.

The group of potholes known as Long Kin West, P 108, was examined, and it was found that no water was flowing into them, nor was there any evidence that a stream had lately occupied any of them, and, consequently, no test was possible.

By visiting these pots during heavy rain, when there is a large amount of local surface drainage, we may be able to connect them with some of the neighbouring springs.

Grey Wife Sike.

On referring to the first report of the Committee, it will be found that an unsuccessful attempt was made to trace the water flowing down P 1, at the foot of Grey Wife Sike.

On that occasion methylene blue was employed, and, as that reagent has since been found to be practically useless for our purposes, we determined to try again with fluorescein.

Accordingly, about half a pound of fluorescein was introduced at P 1 on July 2, and another similar quantity on July 4. This came out at Moses Well, S 7, a large spring on the right bank of Clapham Beck, on the 5th and 6th.

The River Greeta.

The last piece of work undertaken this year was the tracing of the underground course of the main stream in Chapel-le-Dale.

This stream flows underground in many places in normal weather, but when in flood occupies a well-worn channel on the surface.

The upper part of the stream, above Weathercote, is known as Winterscale Beck, the portion between Weathercote and Gods Bridge as Chapel Beck, and from that point down to Ingleton as the river Greeta.

The stream rises on the moors near the tunnel of the Midland Railway, above the Ribblehead Viaduct, and soon sinks in a series of potholes, there being, however, a well-marked open flood channel.

The whole stream again comes to the surface at the mouth of Gate Kirk Cave, S 107, and another large spring a few yards away.

It then flows through several large pools, and again goes underground at P 85, leaving the stream bed dry, to again emerge about seventy yards

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further down at S 109. It again sinks at the foot of Haws Gill, P 87, where it is joined by the water from Eller Keld Spring.

Except in cases of exceptional flood, the bed of the stream below this point is dry, and from the point where Philpin Lane crosses the channel, to Philpin Hole, it is occupied by meadow land, which shows no sign of having been recently overflowed.

In the clough above Weathercote Cave the water can be heard below the stream bed, and actually comes to the surface in several places in wet weather. It emerges in the fine waterfall in Weathercote Cave, and again passes below the limestone at the bottom of that pot.

The water sinking in Weathercote Cave then passes through the pool at the bottom of Hurtle Pot, and finds its way beneath the surface to Gods Bridge, where it finally comes to light, and flows off the carboniferous limestone on to the Silurian rocks some 200 yards farther down stream.

In extremely wet weather Weathercote Cave fills up and overflows at the surface, washing over the carriage drive, and flows into Jingle Pot, and also down the, at other times deserted, river bed.

Hurtle Pot, when the stream is in moderate flood, makes an extremely weird noise, similar to that produced by the inrush of water and air when the plug is removed from the bottom of a lavatory basin, but immeasurably louder. This noise is caused by the suction of air through gigantic eddies produced in the deep pool at the bottom of the pot.

In extremely heavy flood Hurtle Pot fills up and overflows into the surface channel, thus acting in a manner precisely similar to Footnaw's Hole, described in the last report of the committee.

The surface channel from Chapel-le-Dale Church to Gods Bridge is usually dry, but is occupied by the stream when in flood.

The underground channel seems to follow the direction of the open one very closely, as the water can be heard at many points, and appears at the surface in wet weather.

The following is the fluorescein record from which the above has been deduced :—

Two pounds of fluorescein put into the stream just below the mouth of Gate Kirk Cave, on the morning of August 23 : Sank at P 85, and emerged at S 108 at 1 P.M. ; sank at P 86 at 1.30 P.M. ; seen at S 109 and P 87 at 2 P.M.

August 24.—Seen in Weathercote Cave at 9.15 A.M. ; seen in Hurtle Pot at 10 A.M.

August 25.—Arrived at S 112 (Gods Bridge) at 12 noon.

It will be seen that the work on Ingleboro' is now almost completed. It only remains to test two streams which have hitherto proved refractory, and one or two small streams on the west side of the hill. These latter should offer little difficulty, as the main flows on both sides of them have been determined, and their possible range thus limited.

We have been unable as yet to carry out the proposed borings at Turn Dub, owing to the absence of the owner of the property in South Africa, and our consequent inability to obtain the necessary permission.

Through the courtesy of the Yorkshire Ramblers' Club several members of the joint committee were enabled to make the descent of Gaping Gill, the pothole mentioned in the first report of the Committee, and to explore the extensive system of chambers and passages at the bottom of the shaft.

The thanks of the Committee are due to the following gentlemen, who

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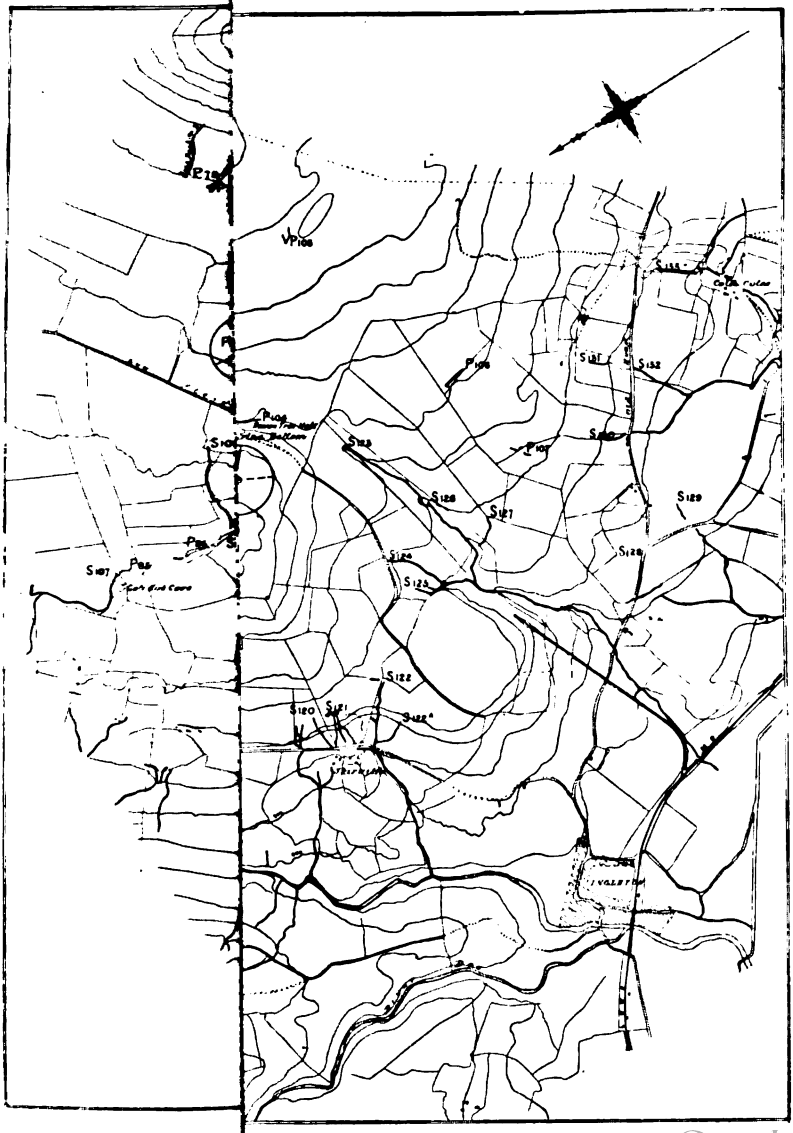

est Yorkshire.

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have kindly assisted them in their work :—Professor Thompson and Mr. E. J. Edwards, of the Yorkshire College ; Mr. Metcalfe, of Weathercote ; Mr. Sydney Calow ; Mr. R. Nowell, of Ribblehead ; Mr. Percy Lamb, of Clapham ; Mr. Taylor, of Crummack ; and Mr. Cook and Mr. Hunt, of Horton-in-Ribblesdale.

The Committee asks to be reappointed, and to be allowed to retain the unexpended balance of the grant made at the Belfast meeting.

Photographs of Geological Interest in the United Kingdom.—Fourteenth Report of the Committee, consisting of Professor JAMES GEIKIE (*Chairman*), Professor W. W. WATTS (*Secretary*), Professor T. G. BONNEY, Professor E. J. GARWOOD, Professor S. H. REYNOLDS, Dr. TEMPEST ANDERSON, Mr. GODFREY BINGLEY, Mr. H. COATES, Mr. A. K. COOMÁRASWÁMY, Mr. C. V. CROOK, Mr. J. G. GOODCHILD, Mr. WILLIAM GRAY, Mr. ROBERT KIDSTON, Mr. J. ST. J. PHILLIPS, Mr. A. S. REID, Mr. J. J. H. TEALL, Mr. R. WELCH, *and* Mr. H. B. WOODWARD. (*Drawn up by the Secretary.*)

THE Committee have to report that during the year 463 new photographs have been received, bringing the total number in the collection to 3,771. This exceeds by 50 the largest number of new photographs previously recorded in a single year, and the yearly average now reaches 268. About 60 additional photographs have been sent in since this Report was written.

The usual geographical scheme is appended. Brecknock, Cardigan, Nairn, and Ross appear for the first time, and very substantial additions are made to Cheshire, Dorset, Norfolk, Yorkshire, Glamorgan, the Channel Islands and Scilly, Inverness, Sutherland, Antrim, and Louth. The following twenty-five counties are still entirely unrepresented :—Cambridge, Huntingdon, Rutland, Carmarthen, Clackmannan, Dumbarton, Dumfries, Kincardine, Kinross, Roxborough, Selkirk, Carlow, Kildare, Kilkenny, King's Co., Leitrim, Longford, Monaghan, Queen's Co., Roscommon, Tyrone, Waterford, Westmeath, Wexford, and Wicklow.

The high standard mentioned in the last Report is maintained, the photographs being usually taken in sets and with a definite geological aim. Mr. W. Jerome Harrison sends two large series taken to illustrate glacial phenomena on the Norfolk and Holderness cliffs. Mr. Morton and Mr. Howard contribute illustrations from Brecknock ; Mr. R. H. Preston from the Scilly Islands ; Mr. Guiton from Jersey ; and Mr. Maidwell from the Nuneaton district. Mrs. Coomáraswámy has taken several series from the north of Scotland and of Ireland ; Mr. Wright a useful set from Dublin ; and Mr. Lamond Howie some interesting Scottish mountain photographs. The Croydon Natural History and Scientific Society continues to illustrate the geology of Surrey ; Dr. Abbott that of Durham ; Mr. Hopkinson that of Bedfordshire ; and Mr. Hodson that of Leicestershire.

The members of the Committee have not been idle, as is testified by Professor Reynolds' series from Dorset, Gloucestershire, Somersetshire, Glamorgan, Antrim, Down, and Kerry ; Mr. Bingley's sets from Cheshire and Yorkshire ; Mr. A. K. Coomáraswámy's series from Ross, Sutherland, and Berwick ; Professor Garwood's contribution from Westmoreland ; Mr. Teall's photographs from Hertfordshire ; and Mr. A. S. Reid's continuation of his series from Eigg and Perthshire.

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To all those contributors named and to the following the Committee desire to tender their warmest thanks for photographs received or help rendered: Mr. J. B. Scrivenor, Mr. C. M. Gillespie, Mr. Howard Fox, Mr. G. T. Atchison, Mr. A. Wheen, Mr. E. M. Wrench, Mr. H. A. Hinton, Mr. R. H. Rastall, Mr. C. H. B. Epps, Mr. F. Greenwood, Mr. A. A. Armstrong, Mr. W. G. Fearnsides, Mr. J. H. Baldock, Mr. N. F. Robarts, Mr. C. G. Cullis, Mr. Caradoc Mills, Mr. G. E. Blundell, Mr. H. W. Monckton, Mr. E. K. Hall, and Mr. H. B. Woodward.

A few photographs have been received for the duplicate series, but will be held over for the present. This collection has been sent during the year to natural history societies at Winchester and Croydon, and accounts of the work have been given by Mr. Whitaker.

—	Previous Collection	Additions (1908)	Total
ENGLAND—			
Bedfordshire	4	2	6
Berkshire	5	—	5
Buckinghamshire	7	1	8
Cambridgeshire	—	—	—
Cheshire	46	23	69
Cornwall	50	7	57
Cumberland	39	4	43
Derbyshire	44	1	45
Devonshire	175	3	178
Dorset	101	35	136
Durham	117	19	136
Essex	6	—	6
Gloucestershire	51	16	67
Hampshire	36	—	36
Herefordshire	1	—	1
Hertfordshire	10	5	15
Huntingdonshire	—	—	—
Kent	79	2	81
Lancashire	68	1	69
Leicestershire	138	6	144
Lincolnshire	6	—	6
Middlesex	7	—	7
Monmouth	5	—	5
Norfolk	23	44	67
Northamptonshire	6	—	6
Northumberland	70	3	73
Nottinghamshire	14	—	14
Oxfordshire	1	—	1
Rutlandshire	—	—	—
Shropshire	51	3	54
Somersetshire	66	4	70
Staffordshire	53	—	53
Suffolk	21	—	21
Surrey	47	7	54
Sussex	12	—	12
Warwickshire	39	5	44
Westmoreland	78	4	82
Wiltshire	5	2	7
Worcestershire	26	—	26
Yorkshire	544	60	604
Total	2,051	257	2,308

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—	Previous Collection	Additions (1908)	Total
WALES—			
Anglesey	5	—	5
Brecknockshire	—	8	8
Cardiganshire	—	1	1
Carmarthenshire	—	—	—
Carnarvonshire	92	4	96
Denbighshire	16	—	16
Flintshire	5	—	5
Glamorganshire	41	13	54
Merionethshire	19	—	19
Montgomeryshire	11	—	11
Pembrokeshire	15	—	15
Radnorshire	20	—	20
Total	224	26	250
CHANNEL ISLANDS	15	23	38
ISLE OF MAN	60	—	60
SCOTLAND—			
Aberdeenshire	6	—	6
Argyllshire	20	3	23
Ayrshire	6	—	6
Banffshire	11	—	11
Berwickshire	4	5	9
Bute	6	—	6
Caithness	4	—	4
Clackmannan	—	—	—
Dumbarton	—	—	—
Dumfries	—	—	—
Edinburgh	47	—	47
Elgin	9	—	9
Fifeshire	24	—	24
Forfarshire	7	—	7
Haddingtonshire	4	—	4
Inverness	115	23	138
Kincardine	—	—	—
Kinross	—	—	—
Kirkcudbright	3	—	3
Lanarkshire	11	—	11
Linlithgow	2	—	2
Nairn	—	2	2
Orkney and Shetland	3	—	3
Perthshire	22	2	24
Renfrewshire	1	—	1
Ross-shire	—	19	19
Roxborough	—	—	—
Selkirk	—	—	—
Stirlingshire	15	—	15
Sutherlandshire	6	42	48
Wigtown	—	—	—
Total	326	96	422

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	Previous Collection	Additions (1903)	Total
IRELAND—			
Antrim	239	34	273
Armagh	2	—	2
Carlow	—	—	—
Cavan	1	—	1
Clare	13	—	13
Cork	2	—	2
Donegal	50	—	50
Down	88	10	98
Dublin	33	6	39
Fermanagh	5	—	5
Galway	29	—	29
Kerry	26	4	30
Kildare	—	—	—
Kilkenny	—	—	—
King's Co.	—	—	—
Leitrim	—	—	—
Limerick	2	—	2
Londonderry	23	—	23
Longford	—	—	—
Louth	1	7	8
Mayo	14	—	14
Meath	2	—	2
Monaghan	—	—	—
Queen's Co.	—	—	—
Roscommon	—	—	—
Sligo	5	—	5
Tipperary	1	—	1
Tyrone	—	—	—
Waterford	—	—	—
Westmeath	—	—	—
Wexford	—	—	—
Wicklow	—	—	—
Total	536	61	597
ROCK STRUCTURES, &c.	96	—	96
FOREIGN	—	—	—
ENGLAND	2,051	257	2,308
WALES	224	26	250
CHANNEL ISLANDS	15	23	38
ISLE OF MAN	60	—	60
SCOTLAND	326	96	422
IRELAND	536	61	597
ROCK STRUCTURES, &c.	96	—	96
FOREIGN	—	—	—
Total	3,308	463	3,771

The collection is stored at the Museum of Practical Geology, Jermyn Street, and the Committee wish to express their thanks to the Director and to Mr. Crook for the care taken of it and the space devoted to it.

The second of the three contemplated issues of the published series of photographs has been sent to subscribers. The issue consists of eighteen half plates, four quarter-plates, and four whole-plates, and it has been

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published in the form of mounted and unmounted prints and lantern-slides. The negatives were contributed by thirteen photographers, and the descriptions by twenty geologists. To all who have thus contributed to the success of the issue the Committee give their best thanks.

The process of selection for the third issue is well advanced, and it is hoped that publication will take place early next year.

The Committee are prepared to publish a second series if there is a demand for it. The number of names at present sent in is only about sixty, and at least twice that number would be required to put the issue on a possible financial basis. The first two issues of the first series show a small profit. The Committee intend to apply one-half to the purposes of the collection, and thus avoid calling upon the Association for any grant for a few years, while they are returning the other half to the subscribers in the form of additional photographs. The subscribers have already received an 'interim dividend' (rather a larger one than the present profits warrant) in the form of four whole-plate photographs and additional slides.

With regard to finances, it seems a good opportunity to state that there has been granted to the Committee since 1889 the sum of 130*l.*, of which they have spent 101*l.* 10*s.* This sum has been used in acquiring, mounting, and storing 3,771 photographs. In other words, the Association has obtained this valuable and unique collection at the cost of rather less than 6½*d.* per print. In addition to this, it possesses a duplicate collection of over 450 prints and slides, and, if the publication scheme continues to turn out well, the money invested by the Association will yield a further similar return for the next four or five years.

Applications by Local Societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

The Committee recommend that they be reappointed, without a grant and with the addition of Mr. W. Jerome Harrison and Mr. W. Whitaker.

FOURTEENTH LIST OF GEOLOGICAL PHOTOGRAPHS.

(To August 17, 1903.)

This list contains the geological photographs which have been received by the Secretary of the Committee since the publication of the last report. Photographers are asked to affix the registered numbers, as given below, to their negatives for convenience of future reference. Their own numbers are added in order to enable them to do so.

Copies of photographs desired can, in most instances, be obtained from the photographer direct, or from the officers of the local society under whose auspices the views were taken.

The price at which copies may be obtained depends on the size of the print and on local circumstances over which the Committee have no control.

The Committee *do not assume the copyright of any photographs* included in this list. Inquiries respecting photographs, and applications for permission to reproduce them, should be addressed to the photographers direct.

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It is recommended that, wherever the negative is suitable, the print be made by the cold-bath platinotype process. The very best photographs lose half their utility, and all their value as documentary evidence, unless accurately described; and the Secretary would be grateful if, whenever possible, such explanatory details as can be given are written on the forms supplied by him for the purpose, and *not on the back of the photograph or elsewhere.* Much labour and error of transcription would thereby be saved. It is well, also, to use a permanent ink for this purpose. A local number by which the print and negative can be recognised should be written on the back of the photograph and on the top right-hand corner of the form.

Copies of photographs should be sent *unmounted* to W. W. Watts, The University, Birmingham, and forms may be obtained from him.

The size of photographs is indicated as follows :—

L = Lantern size.	1/1 = Whole-plate.
1/4 = Quarter-plate.	10/8 = 10 inches by 8.
1/2 = Half-plate.	12/10 = 12 inches by 10, &c.

E signifies Enlargements.

* Indicates that photographs and slides may be purchased from the donors, or obtained through the address given with the series.

LIST I.

ACCESSIONS IN 1902–1903.

ENGLAND.

BEDFORDSHIRE.—*Photographed by* J. HOPKINSON, *F.G.S., Weetwood, Watford.* 1/4.

Regd. No.		
3295	(12) Stone Lane Pits, Heath, Leighton Buzzard.	Ferruginous Sandstone in Lower Greensand, Boulder-clay on top. 1902.
3296	(13) Castle Hill Pit, Clophill, Ampthill.	10′ Clay in thin layers in Lower Greensand. 1902.

BUCKINGHAMSHIRE.—*Photographed by* J. HOPKINSON, *F.G.S., Weetwood, Watford.* 1/4.

3297	(11) Eddleborough Church, near Dunstable.	Outlier of Totternhoe Stone. 1902.

CHESHIRE.—*Photographed by* GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds.* 1/4.

3298	(6117) Meolse, near Hoylake .	Submerged Forest.	1903.
3299	(6118) „ „ „ .	„	„
3300	(6119) „ „ „ .	„	„
3301	(6120) „ „ „ .	„	„
3302	(6121) „ „ „ .	„	„
3303	(6122) „ „ „ .	„	„
3304	(6123) „ „ „ .	„	„
3305	(6124) „ „ „ .	„	„
3306	(6125) „ „ „ .	„	„
3307	(6112) Hilbre Point, near West Kirby.	Bunter Sandstone.	„
3308	(6128) Middle Island, Hilbre .	„	„
3309	(6129) „ „ . .	„	„

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Regd. No.			
3310	(6130)	Hilbre Island . .	Bunter Sandstone. 1903.
3311	(6132)	„ „ North . .	„ Cross-bedding. 1903.
3312	(6136)	„ „ „ . .	„ „ „
3313	(6133)	„ „ . .	„ „ „
3314	(6131)	„ „ . .	„ „ „
3315	(6134)	„ „ . .	„ „ „
3316	(6135)	„ „ . .	„ „ „
3317	(6142)	Higher Bebington . .	Keuper Sandstone, Fault. 1903.
3318	(6141)	„ „ . .	„ „ „
3319	(6140)	„ „ . .	„ „ „
3320	(6138)	„ „ . .	Sandstone slab with Footprints. 1903.

CORNWALL.—*Photographed by* J. B. SCRIVENOR, *M.A., F.G.S.*, 28 *Jermyn Street, S.W.* 1/4.

3321	(1)	Cligga Head . . .	Alternations of Granite and Greisen. 1902.
3322	(3)	„ „ . . .	Greisen Bands. 1902.

Photographed by C. M. GILLESPIE, *M.A., Yorkshire College, Leeds.* 1/4.

3323	( )	Bude	Anticline in Culm. 1902.
3324	( )	„	„ „

Photographed by HOWARD FOX, Mr. SHEPHARD, *and* W. M. HARRISON, *and presented by* HOWARD FOX, *F.G.S., Rosehill, Falmouth.* 1/2 *and* 5/4.

3325	(434)	Jangye-ryn, Gunwalloe .	Contorted Grit and Shale (Ordovician ?). 1900.
3326	(136)	West Kennack, Lizard .	Porphyritic Diorite. 1890.
3327	(135)	Boulder, near Cavouga Rocks, between Caerleon Cove and Kennack Sands.	„ 1888.

CUMBERLAND.—*Photographed by* G. T. ATCHISON, *M.A., Holmwood, Sutton Coldfield.* 1/2.

3328	(43)	Langdale Pikes, from Elterwater.	Borrowdale Rocks. 1902.
3329	(45)	The Bowder Stone, Borrowdale.	„ „ „
3330	(44)	Half-mile below Lodore, Borrowdale.	Quarry in Borrowdale Series. 1902.
3331	(48)	Below Watendlath, Borrowdale.	'The Devil's Punchbowl.' 1902.

DERBYSHIRE.—*Photographed by* A. WHEEN, *Baslow, and presented by* E. M. WRENCH, *Park Lodge, Baslow.* 1/2.

3332	(3)	Cutting in Old Pack-horse Road, N.E. corner of Chatsworth Park.	Boulder-clay. 1899.

DEVONSHIRE.—*Photographed by* H. A. HINTON, *F.G.S., 7 Cranhurst Road, Willesden Green, N.W.* 1/4.

3333	( )	Chagford, Dartmoor .	Dyke of red, schorlaceous Granite. 1900.
3334	( )	Bovey Tracy . . .	Clay-pit in Lignite Beds.

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Photographed by R. H. RASTALL, *B.A., Christ's College, Cambridge.* 1/4.

Regd. No.		
3335	( ) Budleigh Salterton . .	Triassic Pebble-bed. 1903.

DORSET.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4.

3336	(13) Ballard Down . . .	Chalk Sea-stacks. 1902.
3337	(16) Near Handfast Point .	Early stage in formation of Sea-stack. 1902.
3338	(12) Handfast Point . . .	Promontory and Sea-stack of horizontal Chalk. 1902.
3339	(14) „ „ . . .	Stage in formation of Sea-stack. 1902.
3340	(15) Near Handfast Point .	Sea-stacks in horizontal Chalk. 1902.
3341	(33) Peveril Point and Ballard Down.	Chalk and Purbeck Rocks; differential denudation. 1902.
3342	(18) Peveril Point, Swanage .	Weathered surface of Purbeck Marble. 1902.
3343	(21) Near Peveril Point, Swanage.	Weathered surface of *Corbula* bed in Middle Purbeck. 1902.
3344	(17) Durlston Bay . . .	Chert in lower beds of M. Purbeck. 1902.
3345	(19) „ . . .	Weathered suface of 'Cinder Bed' of M. Purbeck. 1902.
3346	(20) „ . . .	Thin bands of 'beef' in M. Purbeck clays. 1902.
3347	(22) „ . . .	Middle and Lower Purbeck. 1902.
3348	(23) Durlston Head . . .	Portland Stone capped by Purbeck. 1902.
3349	(32) „ . . .	Portland Beds. 1902.
3350	(24) Between Tilly Whim and Durlston Head.	Upper beds of Portland Stone. 1902.
3351	(25) Seacombe Quarry . .	Weathering of Portland Stone. „
3352	(26) E. of St. Alban's Head .	„ „ „ „
3353	(27) Dancing Ledge . . .	Portland Stone. 1902.
3354	(28) Dancing Ledge Quarry .	Portland Stone and Purbeck Beds. 1902.
3355	(29) Winspit Quarry . . .	„ „ „ „
3356	(30) Tilly Whim, Durlston Head	Sea-caves in cherty beds of Portland Stone. 1902.
3357	(34) „ „	Chert in Portland Stone. 1902.
3358	(31) E. of St. Alban's Head .	Sea-caves in Portland Stone. 1902.
3359	(35) Emonet Hill and St. Alban's Head.	Portland Beds overlying Kimmeridge Clay. 1902.
3360	(37) Emonet Hill, W. of St. Alban's Head.	Portland Stone and Sand.
3361	(36) Hounstout Cliff . . .	Portland Beds overlying Kimmeridge Clay. 1902.
3362	(39) „ . . .	Portland Stone, Sand, and Kimmeridge Clay. 1902.
3363	(38) Chapman's Pool . . .	Y-shaped valley. 1902.
3364	(40) Between Hencliff and Freshwater Steps.	Lower Kimmeridge Clay and beds of impure Limestone. 1902.
3365	(41) Cliffs W. of Freshwater Steps.	Kimmeridge Clay Cliffs. 1902.
3366	(42) Cliffs E. of Kimmeridge Bay.	Kimmeridge Clay, Stone-bands, and old Coal-workings. 1902.
3367	(43) Hencliff and Kimmeridge Bay.	Ledges due to Stone-bands in Kimmeridge Clay. 1902.
3368	(44) Between Broad Bench and Kimmeridge Bay.	Kimmeridge Ledges. 1902.
3369	(45) W. side of Kimmeridge Bay.	Kimmeridge Clay and Stone-bands. 1902.
3370	(46) Near Worth Matravers .	Terraces (lynchets) probably due to ploughing. 1902.

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DURHAM.—*Photographed by* G. ABBOTT, *M.R.C.S.*, 33 *Upper Grosvenor Road, Tunbridge Wells.* 1/2.

Regd. No.		
3734	(140) Fulwell Hill, Quarry in Magnesian Limestone . .	'Flag' beds, 20" Marl, and part of lowest cellular Limestone bed. 1902.
3735	(141) Fulwell Hill, Quarry in Magnesian Limestone . .	'Flag' beds, 20" Marl, and part of lowest cellular Limestone bed. 1902.
3736	(151) Fulwell Hill, Quarry in Magnesian Limestone . .	'Flag' beds, 20" Marl, and part of lowest cellular Limestone bed. 1902.
3737	(152) Fulwell Hill, Quarry in Magnesian Limestone . .	'Flag' beds, 20" Marl, and part of lowest cellular Limestone bed. 1902.
3738	(167) Fulwell Hill, Quarry in Magnesian Limestone . .	'Flag' beds, 20" Marl, and part of lowest cellular Limestone bed. 1902.
3739	(193) Fulwell Hill, Quarry in Magnesian Limestone . .	Concretion; spherical 'honeycomb' (a). 1902.
3740	(194) Fulwell Hill, Quarry in Magnesian Limestone . .	Concretion; spherical 'honeycomb' (a). 1902.
3741	(182) Fulwell Hill, Quarry in Magnesian Limestone . .	'Honeycomb' (a) and (b) *in situ*. 1902.
3742	(137) Fulwell Hill, Quarry in Magnesian Limestone . .	„ (b). 1902.
3743	(221) Fulwell Hill, Quarry in Magnesian Limestone . .	„ (c), early stage. 1902.
3744	(159) Fulwell Hill, Quarry in Magnesian Limestone . .	'Coralloid' bed (part of 'flags'). 1902.
3745	(163) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „
3746	(158) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „
3747	(183) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „
3748	(180) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „
3749	(179) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „
3750	(188) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „
3751	(172) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „
3752	(187) Fulwell Hill, Quarry in Magnesian Limestone . .	„ „ „

GLOUCESTERSHIRE.—*Photographed by* Professor S. H. REYNOLDS, *M.A.*, *F.G.S., University College, Bristol.* 1/2 *and* 1/4.

3371	(55) Cutting W. of Stoke Gifford Station.	Lower Lias and Rhætic Beds. 1902.
3372	(56) Cutting W. of Stoke Gifford Station.	Zone of *A. planorbis* overlying Rhætic 1902.
3373	(57) Near Stoke Gifford Station	Red Marl faulted against Rhætic and Tea-green Marl. 1902.
3374	(58) Stoke Gifford Station .	Red Marl faulted against Rhætic and Tea-green Marl. 1902.
3375	(59) „ „ .	Red Marl faulted against Rhætic and Tea-green Marl. 1902.
3376	(60) East of Lilliput, Chipping Sodbury.	Block of Rhætic Bone-bed. 1902.
3377	(61) E. of Chipping Sodbury .	Rhætic and Lower Lias. 1902.
3378	(62) Half-mile E. of Lilliput, Chipping Sodbury.	Rhætic resting unconformably on Old Red Sandstone. 1902.
3379	(63) Cutting, E. end of Sodbury Tunnel.	Great Oolite and Forest Marble. 1902.

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Regd. No.		
3380	(61) Cutting S. of Badminton .	Forest Marble. 1902.
3381	(66) „ „ .	„ „
3382	(72) Aust Cliff	Keuper Marl and Rhætic Beds. 1902.
3383	(68) „	Juxtaposed faults. 1902.
3384	(69) „	Gypsum in Keuper Marl. 1902.
3385	(70) „	„ „ „
3386	(71) „	„ „ „

HERTFORDSHIRE.—*Photographed by* J. J. H. TEALL, *M.A., F.R.S.*, 28 *Jermyn Street, S.W.* 1/4.

3387	(1) Pinner's Cross, Smith's End, S. of Barley, near Royston.	Inclined Chalk and Boulder-clay banked up against it. 1903.
3388	(2) W. of Newsell's Park, N. of Barkway, near Royston.	Chalk greatly disturbed, with Boulder-clay underlying it. 1903.
3389	(3) W. of Newsell's Park, N. of Barkway, near Royston.	Chalk greatly disturbed, with Boulder-clay underlying it. 1903.
3390	(4) N. of Reed, near Royston .	Chalk arching over, glacial disturbance. 1903.
3391	(5) „ „ .	Chalk arching over, glacial disturbance. 1903.

KENT.—*Photographed by* G. ABBOTT, *M.R.C.S.*, 33 *Upper Grosvenor Road, Tunbridge Wells.* 1/2.

3753	(8) Opera House, Tunbridge Wells.	Earth Creep. 1902.
3754	(9) Opera House, Tunbridge Wells.	„ „

LANCASHIRE.—*Photographed by* *F. GREENWOOD, 5 *St. Mary's Gate, Rochdale.* 1/2.

3392	( ) Blackstone Edge, Rochdale	Roman Road. 1895.

LEICESTERSHIRE.—*Photographed by* G. HODSON, *M.Inst.C.E.*, *Loughborough.* 1/4.

3393	( ) Blackbrook, Charnwood .	Trench cutting Blackbrook Rocks, looking E.
3394	( ) „ „ .	Trench cutting Blackbrook Rocks, looking E.
3395	( ) „ „ .	Trench cutting Blackbrook Rocks, looking W.
3396	( ) „ „ .	Trench cutting Blackbrook Rocks, looking W.
3397	( ) „ „ .	Trench cutting Blackbrook Rocks, looking N.W.
3398	( ) „ „ .	Trench cutting Blackbrook Rocks, looking N.

NORFOLK.—*Photographed by* W. JEROME HARRISON, *F.G.S.*, 52 *Claremont Road, Handsworth, Birmingham.* 1/2 *and* 1/1.

3399	(1897) Trimingham . . .	Drift Cliffs. 1896.
3400	(1895) „ . . .	„ „
3401	(1850) Cromer	Mr. Savin's collection of bones from the Forest Bed. 1896.
3402	(1862) Sidestrand Beach . .	'Mud glacier' from the drift cliffs. 1896.
3403	(1899) Sidestrand, E. of Cromer	Old Church Tower on cliffs. 1896.

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Regd. No.		
3404	(1794) Half a mile E. of Cromer	Contorted Drift. 1896.
3405	(683) Beeston Regis . .	Drift Plain between cliffs and hills. 1896.
3406	(1829) Cliffs W. of Cromer .	Drift, with included Chalk Boulders. 1896.
3407	(1818) „ .	Drift. 1896.
3408	(1825) „ .	'Elbow' in Contorted Drift. 1896.
3409	(1836e) „ .	Contorted Drift. 1896.
3410	(1830) W. end of Cromer . .	„ „
3411	(692) Near Runton . .	„ „
3412	(1817) Runton Cliffs . .	„ „
3413	(1836) „ . .	„ „
3414	(1824) Runton Gap . . .	Sandy Drift. 1896.
3415	(1816) „ . . .	„ „
3416	(1778) West Runton . . .	Loamy Drift (contorted). 1896.
3417	(698) Runton Cliffs . . .	Large Chalk Boulder. 1896.
3418	(700) Cliffs, near Runton .	„ „ „
3419	(690) Runton	„ „ „
3420	(699) Runton Cliffs . . .	Long Chalk Boulder. 1896.
3421	(696) Beeston, E. of Sheringham.	Folds in Chalk, covered by Drift. 1896
3422	(695) „ „	„ „ „
3423	(1870) „ „	„ „ „
3424	(1823) „ „	„ „ „
3425	(693) E. of Sheringham . .	Contorted Drift. 1896.
3426	(686) Cliffs, E. of Sheringham	„ „
3427	(1822) „ „ .	Drift. 1896.
3428	(1836d) E. end of Sheringham Beach.	Contortions in Drift. 1896.
3429	(501) E. end of Sheringham .	Contorted Drift. 1896.
3430	(1877) Beeston Beach . .	Paramoudra. 1896.
3431	(1777) Sheringham Beach .	Paramoudra in Chalk. 1896.
3432	(1836a) „ .	Ring of Flint. 1896.
3433	(1834) Cliffs, near Sheringham .	Contorted Drift. 1896.
3434	(1894) „ „ .	Large Chalk Boulder. 1896.
3435	(691) W. of Sheringham .	„ „ „
3436	(694) „ .	Pinnacle of Chalk, embedded in Drift. 1896.
3437	(1833) „ .	Pinnacle of Chalk, embedded in Drift. 1896.
3438	(1820) „ .	Pinnacle of Chalk, embedded in Drift. 1896.
3439	(1821) „ .	'Stone-bed.' 1896.
3440	(1836b) Upper Sheringham .	Basalt Boulders. 1896.
3441	(508) Weybourn . . .	Chalk covered by Clay. 1896.
3442	(496) Coast W. of Weybourn .	Pebble Beach and Lagoon. 1896.

NORTHUMBERLAND.—*Photographed by* A. A. ARMSTRONG, *M.A.* 1/2.

3443	(1) Bamborough Castle . .	Junction of Whin Sill and Carboniferous Limestone. 1902.
3444	(2) Farne Island and shore opposite.	Thin bedding, folding and jointing in Carboniferous Rocks. 1902
3445	(3) 'Limestone Bank,' 2 m. W. of Chollerford.	Outer fosse of Roman Wall cut out of Basalt. 1902.

SHROPSHIRE.—*Photographed by* W. G. FEARNSIDES, *B.A., F.G.S., Sidney Sussex College, Cambridge.* 5/4.

3446	(5) Hope Dingle, near Minsterley.	'Boulder-bed' in Arenig Ash, 1902.

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Regd. No.			
3447	(11) Lower Ashes Hollow, Longmynd.	Longmyndian Scenery.	1902.
3448	(12) Upper Ashes Hollow, Longmynd.	„	„ „

SOMERSET.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4.

3449	(48) Goblin Combe . . .	Dry Valley in Carboniferous Limestone. 1902.
3450	(47) „ . . .	Dry Valley in Carboniferous Limestone. 1902.
3451	(49) „ . . .	Disintegration of Carboniferous Limestone by tree-roots. 1902.
3452	(50) „ . . .	Disintegration of Carboniferous Limestone by tree-roots. 1902.

SURREY.—*Photographed by* J. H. BALDOCK, 3 *St. Leonard's Road, Croydon, and sent through the Croydon Natural History and Scientific Society.* 1/2.

3453	( ) Croham Hurst, Croydon .	Conglomerate. 1901.
3454	( ) Bacteria Tanks, Beddington.	Shelly Woolwich Beds. 1902.
3455	( ) Bacteria Tanks, Beddington.	„ „ „
3456	( ) Foundations of Woldingham Fort, facing N.	Red Clay-with-flints in Chalk 'Pipes.' 1902.
3457	( ) Foundations of Woldingham Fort, facing S.	„ „ „ „
3458	( ) Foundations of Woldingham Fort, facing E.	„ „ „ „
3459	( ) Foundations of Woldingham Fort, facing W.	„ „ „ „

WARWICK.—*Photographed by* F. T. MAIDWELL, 50 *Compton Road, Wolverhampton.* 1/4.

3460	(1) Moor Wood, Chapel End, near Nuneaton.	Unconformity, Coal-measures on Stockingford Shales. 1899.
3461	(2) Moor Wood, Chapel End, near Nuneaton.	Soil Creep. 1899.
3462	(3) Midland Quarry, Nuneaton	Quartzite and Diorite Sill, Unconformably overlain by Keuper Sandstone. 1898.
3463	(4) Near Church, Radford, Coventry.	Boulder of Charnwood Syenite. 1897.
3464	(5) Near Church, Radford, Coventry.	„ „ „

WESTMORELAND.—*Photographed by* Professor E. J. GARWOOD, *M.A., F.G.S., University College, London.* 1/4.

3292	( ) High Cup Nick, Appleby	Valley cut in Whin Sill.
3293	( ) „	„ „

Photographed by GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds.* 1/4.

3465	(6084) Kirkby Stephen, Bed of River Eden.	Jointing in Lower Brockram. 1902.
3466	(6085) Kirkby Stephen, Bed of River Eden.	„ „ „

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WILTSHIRE.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4.

Regd. No.		
3467	(65) Cutting N.W. of Hullavington.	Forest Marble. 1901.
3468	(67) Cutting N.W. of Hullavington.	„ „

YORKSHIRE.—*Photographed by* W. JEROME HARRISON, *F.G.S., 52 Claremont Road, Handsworth, Birmingham.* 1/1 *and* 1/2.

3469	(368) Flamborough Head. .	Chalk Cliffs, showing coast-erosion. 1898.
3470	(361) S.W. of Flamborough Head	Drift on Chalk. 1898.
3471	(383) „ „	Caves in Chalk. 1898.
3472	(886) Near Danes' Dyke, Flamborough.	Chalk. 1898.
3473	(893) North Sea Landing, Flamborough.	Drift on Chalk. 1898.
3474	(894) North Sea Landing, Flamborough.	„ „
3475	(897) South Landing, Flamborough.	„ „
3476	(900) King Rock, Flamborough Head.	Boulder-clay on Chalk. 1898.
3477	(2070) Thornwick Bay, Flamborough.	Drift on Chalk. 1898
3478	(2072) Thornwick Bay, Flamborough.	„ „
3479	(2077) Thornwick Bay, Flamborough.	„ „
3480	(2078) Near Thornwick Bay .	„ „
3481	(884) Sewerby, Flamborough .	Buried Cliff. 1898.
3482	(375) Hilderthorpe Cliffs, S. of Bridlington.	Purple Boulder-clay. 1898.
3483	(374) Hilderthorpe Cliffs, S. of Bridlington.	Stratification in Boulder-clay. 1898.
3484	(882) Hilderthorpe Cliffs, S. of Bridlington.	Drift. 1898.
3485	(594) Hilderthorpe Cliffs, S. of Bridlington.	„ „
3486	(378) Hilderthorpe Cliffs, S. of Bridlington.	Lamination in Drift. 1898.
3487	(883) Hilderthorpe Cliffs, S. of Bridlington.	Boulder-clay, Loams, and Gravels. 1898.
3488	(377) Hilderthorpe Cliffs, S. of Bridlington.	Drift. 1898.
3489	(595) Hilderthorpe Cliffs, S. of Bridlington.	„ „
3490	(376) Hilderthorpe Cliffs, S. of Bridlington.	„ „
3491	(881) Hilderthorpe Cliffs, S. of Bridlington.	„ „

Photographed by GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds* 1/2 *and* 1/4.

3492	(6111) Meanwood Valley, Leeds.	Fossil Tree in Gannister. 1902.
3493	(6088) Hambleton Quarry, Bolton Abbey Station.	Contorted Yoredale Limestones. 1902
3494	(6091) Hambleton Quarry, Bolton Abbey Station.	„ „ „ „

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Regd. No.		
3495	(6094) Hambleton Quarry, Bolton Abbey Station.	Contorted Yoredale Limestones. 1902.
3496	(6095) Hambleton Quarry, Bolton Abbey Station.	" " " "
3497	(6097) Brimham Rocks, near Pateley Bridge, Nidderdale.	Millstone Grit; atmospheric erosion. "
3498	(6098) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3499	(6100) Brimham Rocks, near Pateley Bridge, Nidderdale.	" 'Dancing Bear.' "
3500	(6101) Brimham Rocks, near Pateley Bridge, Nidderdale.	" atmospheric erosion. "
3501	(6102) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3502	(6103) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3503	(6105) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3504	(6106) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3505	(6107) Brimham Rocks, near Pateley Bridge, Nidderdale.	" " "
3506	(6070) Penyghent, from near Hull Pot.	Mountain Limestone and Millstone Grit. 1902.
3507	(6072) Hull Pot, Horton-in-Ribblesdale.	Pot-hole in Carboniferous Limestone. 1902.
3508	(6071) Hull Pot, Horton-in-Ribblesdale.	" " " "
3509	(6059) Alum Pot, near Selside, Ribblesdale.	300 feet deep, in Carboniferous Limestone. 1902.
3510	(6067) Turn Dub, near Horton-in-Ribblesdale.	Exit for water from Alum Pot. 1902.
3511	(6066) Turn Dub, near Horton-in-Ribblesdale.	" " " "
3512	(6068) Footnaw's Hole, Ribblesdale.	" " " "
3513	(6069) Footnaw's Hole, Ribblesdale.	" " " "
3514	(6062) Upper part of Long Churn, Ribblesdale.	Pot-hole in Carboniferous Limestone. 1902.
3515	(6062a) Upper part of Long Churn, Ribblesdale.	" " " "
3516	(6063) Entrance to Long Churn, near Selside, Ribblesdale.	" " " "
3517	(6061a) Entrance to Long Churn, near Selside, Ribblesdale.	" " " "
3518	(6064) Dickon Pot, near Selside, Ribblesdale.	Interior of Pot-hole in Carboniferous Limestone. 1902.
3519	(6069) Horton Scar, N.W. side of Penyghent, Ribblesdale.	Carboniferous Limestone. 1902.
3520	(6073) Hunt Pot, near Horton-in-Ribblesdale.	Pot-hole in Carboniferous Limestone. 1902.
3521	(6075) Hunt Pot, near Horton-in-Ribblesdale.	" " " "
3522	(6074) Hunt Pot, near Horton-in-Ribblesdale.	" " " "
3523	(6078) Bed of River Bain, Bainbridge.	Yoredale Limestone. 1902.
3524	(6079) Lund's Fell, near Hawes Junction.	Source of River Ure. 1902.
3525	(6081) Hell Gill, Lund's Fell.	Source of River Eden. 1902.

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Regd. No.		
3526	(6083) Hell Gill, Lund's Fell.	Source of River Eden. 1902.
3527	(6086) Clapham Beck Head.	Outlet of stream from Gaping Gill. 1902.
3528	(6087) Crummack Dale, near Clapham, E. side.	Carboniferous Limestone resting unconformably on Silurian Grits. 1902.

WALES.

BRECKNOCK.—*Photographed by* P. MORTON, *M.A., Christ's College, Brecon, and presented by* F. T. HOWARD, *M.A., F.G.S.* 1/2.

3529	(1) Canal Aqueduct, Brecon .	Taken before the frost. 1890.
3530	(2) „ „ .	Effect of frost on leakage. 1895.
3531	(3) „ „ .	„ „ „
3532	(4) „ „ .	„ „ „
3533	(5) Rhŷd-goch Falls, Brecon, River Gwdi.	Grits amongst Shales and Clays. 1891.
3534	(6) Cilieni, just entering River Usk, 8 m. W. of Brecon.	Usk cuts down the more rapidly as it follows the outcrop of Old Red Sandstone Clays. 1890.
3535	(7) Llyn-cwm-llwch . . .	Glacial Mounds. 1900.
3536	(8) Near Llyn-cwm-llwch, N. of y Fan-cwm-du.	Moraine at foot of Old Red Sandstone—escarpment. 1900.

CARDIGAN.—*Photographed by* C. G. CULLIS, *Royal College of Science, South Kensington, S.W.* 1/4.

3537	( ) New Quay, Cardigan Bay.	Llandovery (?) Rocks; relation of Cleavage to hard and soft beds. 1903.

CARNARVON.—*Photographed by* CARADOC MILLS, *Plas Helyg, Llanrwst.* 1/4.

3538	(1) Near Llyn Geirionydd, Trefriw.	Boulders. 1902.
3539	(2) Near Llyn Geirionydd, Trefriw.	Perched Block. 1902.
3540	(3) Near Llyn Geirionydd, Trefriw.	„ „

Photographed by W. G. FEARNSIDES, *B.A., F.G.S., Sidney Sussex College, Cambridge.* 5/4.

3541	( ) Tu-hwnt-yr-bwlch, near Portmadoc.	Tremadoc Slates with fossils. 1902.

GLAMORGAN.—*Photographed by* G. E. BLUNDELL, *F.G.S., Wellington College, Berks.* 5/4.

3542	( ) Spritsail Tor, Gower.	Cave and Kitchen Midden. 1902.

Photographed by H. W. MONCKTON, *F.G.S., F.L.S.*, 3 *Harcourt Buildings, Temple, E.C.* 1/4.

3543	(1694) Cliff between Caswell Bay and Brandy Cove.	Raised Beach. 1902.

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Photographed by Professor S. H. Reynolds, *M.A., F.G.S., University College, Bristol.* 1/4.

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3544	(1) Mumbles Head . . .	Dip of Carboniferous Limestone. 1902.
3545	(3) Above the Lifeboat House, Mumbles Head.	Dolomitisation of Carboniferous Limestone. 1902.
3546	(7) W. of Mumbles Head . .	Honeycomb weathering of Carboniferous Limestone. 1902
3547	(5) E. of Oystermouth . .	Dolomitised patches in Carboniferous Limestone. 1902.
3548	(6) „ „ . .	Dolomitised patches in Carboniferous Limestone. 1902.
3549	(4) „ „ . .	Dolomitised patches in Carboniferous Limestone. 1902.
3550	(8) Bishopston Common . .	Stream disappearing in 'daw-pit.' 1902.
3551	(2) Limeslade Bay and Twt Hill	Dip of Carboniferous Limestone and old shore platform. 1902.
3552	(9) Limeslade Bay	Weathered surface of 'Head.' 1902.
3553	(10) Between Limeslade Bay and Langland Bay.	Raised Beach on Carboniferous Limestone. 1902.
3554	(11) Between Limeslade Bay and Langland Bay.	Raised Beach on Carboniferous Limestone. 1902.

THE CHANNEL ISLANDS.

Jersey.—*Photographed by* E. F. Guiton, 8 *Victoria Crescent, Jersey.* 1/2.

3555	(1) 'Creux Gabourel' . .	Three levels of Sea-beaches. 1901.
3556	(2) St. Laurence Valley . .	Ripple-marked Shale. 1902.
3557	(3) Near Rozel Bay, Le Sauchet.	Marine erosion of Conglomerate. 1902.
3558	(4) Portelet Bay . . .	Raised Beach. 1902.
3559	(5) „ . . .	„ „
3560	(6) 'Fosse Vourin,' St. Brelade.	'Creux'; formation of Blowhole. 1902.
3561	(7) Le Pinacle, St. Ouen's. .	Granite and Diabase. 1902.
3562	(8) „ „ . .	„ „ „
3563	(9) „ „ . .	Vein of Diabase and Marmite. 1902.
3564	(10) „ „ . .	'Marmite' or marine pot-hole. „
3565	(11) Blanches Banques, Quenvais, St. Brelade.	Mound of Blown-sand. 1902.
3566	(12) Blanches Banques, Quenvais, St. Brelade.	„ „ „
3567	(13) Blanches Banques, Quenvais, St. Brelade.	„ „ „

Scilly Islands.—*Photographed by* R. H. Preston, *Alverne House Penzance.* 1/1.

3568	(18) Peninnis Head, St. Mary's.	Weathering of Granite. 1895.
3569	(27) Dick's Carn, St. Mary's .	„ „ „
3570	( ) 'The Tooth Rock,' St. Mary's.	„ „ „
3571	(22) 'The Monk's Cowl,' St. Mary's.	„ „ „
3572	( ) 'The Pulpit Rock,' St. Mary's.	„ „ „
3573	(29) 'The Loaded Camel,' St. Mary's.	„ „ „
3574	(75) 'The Punch-bowl.' St. Agnes	„ „ „
3575	(26) 'The Drum Rock,' St. Mary's.	„ „ „

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Regd. No.		
3576	( ) 'The Giant's Chair,' St. Mary's.	Weathering of Granite. 1895.
3577	(72) 'The Nag's Head,' St. Agnes.	„ „ „

SCOTLAND.

ARGYLLSHIRE.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S.* (a), *and* Mrs. COOMÁRASWÁMY (b), *Walden, Worplesdon, Guildford.* 1/4.

3578	(79a) S. of Dun Dubhaidh, Iona.	Schistose Marble and Gneisses. 1902.
3579	(19b) Balephetrish, Tiree . .	Well-foliated Marble. 1902.
3580	(20b) „ „ . .	Weathered Marble, with Forsterite, Spinel, &c. 1902.

BERWICKSHIRE.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S.* (a) *and* Mrs. COOMÁRASWÁMY (b), *Walden, Worplesdon, Guildford.* 1/4.

3581	(1a) 'The Leithies,' near North Berwick.	Dyke in Carboniferous Tuff. 1902.
3582	(2a) 'The Leithies,' near North Berwick.	Bedded Carboniferous Tuff, with large Bomb. 1902.
3583	(3a) 'The Leithies,' near North Berwick.	Bedded Carboniferous Tuff, with large ejected blocks. 1902.
3584	(4a) North Berwick Law . .	Carboniferous Trachyte 'Neck,' 'Crag and Tail.' 1902.
3585	(28b) The Bass Rock, from near North Berwick.	Carboniferous Trachyte. 1902.

INVERNESS.—*Photographed by* W. LAMOND HOWIE, *Hanover Lodge, Harrow.* 5/4, 12/4, 18/4, &c.

3294	( ) The 'Parallel Roads,' Glenroy.	Looking N.N.W. from slope of Bohuntine Hill. 1896.
3587	( ) Scuir-na-Gillean, Skye .	Gabbro. 1903.
3588	( ) Summit of Blaven, from Marscow.	„ „
3589	( ) The Cuillins, from N. .	1903.
3590	( ) The Cuillins and Glen Sligachan, from E.	„
3591	( ) Glen Brittle and the Cuillins, from Col to Loch Brittle, from W.	„
3592	( ) Coire-na-Creiche . .	„
3610	( ) Ben Alder and Carn Dearg.	From Meall Cruaidh. 1902.

Photographed by A. S. REID, *M.A., F.G.S., Trinity College, Glenalmond, Perth.* 1/2, *one E.*

3593	(SE 27) Island of Eigg, from Muck.	Outline of Scuir. 1901.
3594	(SE 22) E. end of Scuir of Eigg, from sea.	Steps of Basalt, surmounted by Scuir Pitchstone. 1901.
3595	(SE 6) Scuir of Eigg, from E.N.E.	Position of tributary valley (Cornbheinn) in relation to Scuir valley. 1901.
3596	(SE 17) E. end of Scuir of Eigg, from S.E.	Pitchstone occupying old valley in Basalts. 1901.
3597	(SE 29) Bidein Boidheach, N.W. end of Scuir of Eigg. (E.), from sea.	River Conglomerate under Pitchstone and resting on eroded Basalt. 1901.

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3598	(SE 33) Scuir of Eigg, from Beannan Breaca.	Physical features of Scuir ridge. 1901.
3599	(SE 31) Scuir of Eigg, from high ground S.W. of Loch Beinn Tighe.	Pitchstone in main and tributary valleys. 1901.
3600	(SE 35) E. prolongation of Scuir of Eigg, from N.W.	Pitchstone Ridge, to show varying trend. 1901.
3601	(SE 11) Scuir of Eigg, Eastern prolongation, from W.N.W.	Relation of main to tributary valley. 1901.
3602	(SE 34) Scuir of Eigg, from knoll N.W. of Loch an Nighean Dughaill.	Relation of main to tributary valley. 1901.
3603	(SE 40) Shore of Laig Bay, Eigg.	Basalt Dyke in Jurassic Rocks. 1901.
3604	(SE 9) Cleadale, Eigg . .	Bedded Basalts of Small Isles Plateau. 1901.
3605	(SE 36) S. Shore, Ruadh'an Tancaird, Eigg.	Two Pitchstone Dykes in Basalt. 1901.
3606	(SE 37) S. Shore, Ruadh'an Tancaird, Eigg.	Pitchstone Dyke in amygdaloidal Basalt. 1901.
3607	(SE 38) S. Shore, Ruadh'an Tancaird, Eigg.	Pitchstone Dyke in amygdaloidal Basalt. 1901.

NAIRN.—*Photographed by* E. K. HALL, *Nairn, N.B.* $7\frac{1}{2}/5$.

3608	( ) Tom Riach, near Clava .	Boulder. 1901.
3609	( ) " " .	" "

PERTHSHIRE.—*Photographed by* A. S. REID, *M.A., F.G.S., Trinity College, Glenalmond, Perth.* 1/2.

3611	(CL 20) Wester Glenalmond, near Auchnafree.	River Terrace and Moraine Mounds. 1901.
3612	(CL 36) Sma' Glen, Glenalmond	A few hours' Pluvial Denudation. 1901.

ROSS-SHIRE.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S.* (a) *and* Mrs. COOMÁRASWÁMY (b), *Walden, Worplesdon, Guildford.* 1/4.

3586	(67a) River Kanaird, near Road	Erosion of earlier Terrace by river; deposition inside curve of stream. 1902.
3613	(62a) Hills above Hotel, Gairloch.	Perched Block. 1902.
3614	(61a) Hills above Hotel, Gairloch.	" "
3615	(64a) Shore, Gairloch . .	Ripple-marked Sand. 1902.
3616	(38b) Gairloch Hotel . .	50′ Raised Beach. 1902.
3617	(63a) Shore, Gairloch . .	Torridon Sandstone, Basement Conglomerate. 1902.
3618	(65a) " " . .	Augen-gneiss, vertical foliation. 1902.
3619	(76a) Head of Loch Maree, from Kinlochewe Forest.	Kinlochewe River, and Delta filling lake. 1902.
3620	(73a) Ben Eadh, near Loch Maree.	Quartzite scenery and glaciation. 1902.
3621	(35b) Ben Eadh, near Loch Maree.	" " " "
3622	(36b) Ruadh Stac Mor and Sail Mor, from Glen Goudie, Loch Maree.	White Quartzite cap on mountains of Torridon Sandstone; moraines. 1902.
2 23	(37b) Half-mile N.E. of Furnes, Letterewe, Loch Maree.	Contorted Limestone in Gneiss. 1902.

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3624	(74a) Kinlochewe Forest, Loch Maree.	Quartzite scenery, Eastern Schists. 1902.
3625	(75a) Glen Goudie, Loch Maree	Wilderness of Moraines. 1902.
3626	(72a) Opposite Ullapool, on Loch Broom.	Outcrop of Thrust-planes. 1902.
3627	(69a) Braemor, head of Loch Broom.	Gorge and small Waterfalls in Eastern Schists. 1902.
3628	(39b) Corryhalloch, Braemor .	Gorge and small Waterfalls in Eastern Schists. 1902.
3629	(8a) Oykell Bridge . . .	Monotonous scenery of Eastern Schists. 1902.
3630	(9a) „ „ . . .	Silvery Eastern Schists. 1902.

SUTHERLAND.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S.* (a) *and* Mrs. CQOMÁRASWÁMY (b), *Walden, Worplesdon, Guildford.* 1/4.

3631	(14a) Coul Mor, from head of Loch Veigatie.	Torridon Sandstone hill with Quartzite summits. 1902.
3632	(82a) Summit of Coul Mor .	Quartzite on Torridon Sandstone. 1902.
3633	(21a) Near Summit of Coul Mor	Weathered Torridon Sandstone. 1902.
3634	(18a) Canisp and Suilven, from Glen Canisp, near Lochinver.	Torridon Sandstone hills. 1902.
3635	(29b) Suilven, from Coul Mor .	Torridon Sandstone Mountain and Gneiss Plateau. 1902.
3636	(15a) Canisp and Suilven, from S. of Loch Urigill.	Torridon Sandstone. 1902.
3637	(12a) Tributary of Alt Achaidh, W. of Cromalt.	Peat on Drift (Alluvial Cone). 1902
3638	(11a) Tributary of Alt Achaidh, W. of Cromalt.	Peat on Drift with tree stumps. 1902.
3639	(10a) Tributary of Alt Achaidh, W. of Cromalt.	„ „ „ „
3640	(5a) Cnoc an t'Sassunaich (Knockan Cliff), Ullapool.	General view. 1902.
3641	(7a) Cnoc an t'Sassunaich (Knockan Cliff), Ullapool.	Sole of Thrust-plane. 1902.
3642	(3a) S.W. shore of Cama Loch.	Torridon Sandstone, Basement Conglomerate. 1902.
3643	(31b) Sronchrubie Cliff, Inchnadamff.	Edge of Limestone Plateau. 1902.
3644	(29a) Inchnadamff . . .	Durness Limestone Plateau and Sronchrubie Cliff. 1902.
3645	(28a) Cnoc an Droighinn, Inchnadamff.	'Pipe-rock'; half-inch pipes. 1902.
3646	(22a) Traligill Burn, Inchnadamff.	Conimheall (Ben More); Major Thrust-plane in Durness Limestone. 1902.
3647	(23a) Traligill Burn, Inchnadamff.	Conimheall (Ben More); Major Thrust-plane in Durness Limestone and dry valley. 1902.
3648	(24a) Traligill Burn, Inchnadamff.	Conimheall (Ben More); Major Thrust-plane in Durness Limestone and dry valley. 1902.
3649	(31ab) Alt Uamh, near Inchnadamff.	Large stream issuing from under Limestone hill. 1902.
3650	(32b) Near Loch Gillaroo, Inchnadamff.	Stream disappearing into Swallow-hole. 1902.
3651	(25a) Conimheall (Ben More), Assynt.	Quartzite. 1902.
3652	(33b) Top of Conimheall . .	Weathering of Quartzite. 1902.
3653	(31a) From Cnoc an Droighinn.	Outliers above Ben More Thrust-plane, 1902.

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3654	(56a) Old Man of Stoer . .	Stack of Torridon Sandstone. 1902.
3655	(55a) " " . .	" " " "
3656	(32a) Uamh Rhuadhrige, near Kylesku.	Nearly horizontal Foliation in Hebridean Gneiss. 1902.
3657	(33a) Half-mile S.S.W. of Kylesku Inn.	'Slack' due to weathering out of Basic Dyke in Gneiss. 1902.
3658	(34b) Aird Du Loch, from S. side of Loch Glencoul.	Glencoul Thrust-plane. 1902.
3659	(38a) Glen Dhu, from Unapool, near Kylesku.	" " "
3660	(39a) From base of Stack of Glencoul.	Cliff of Eastern Schists; Moine Thrust-plane. 1902.
3661	(36a) Loch Glencoul, N. side .	Glencoul Thrust-plane; Gneiss on Durness Limestone. 1902.
3662	(41a) Stack of Glencoul, from N.N.W.	Moine Schists, Moine Thrust, Cambrian rocks, and Gneiss. 1902.
3663	(30b) Quinaig, from Kyle Strome.	Torridon Sandstone Mountain and Gneiss Plateau. 1902.
3664	(44a) N. of Scourie . . .	Hummocky (glaciated?) Gneiss. 1902.
3665	(45a) Creag a mhail, Scourie Bay.	Basic Augen in Gneiss. 1902.
3666	(52a) Quinaig, Suilven, &c., from Scourie.	Torridon Sandstone and Gneiss. 1902.
3667	(50a) 1 m. E.S.E. of Laxford Bridge.	Basic Auge in Gneiss. 1902.
3668	(48a) Ben Stack . . .	Gneiss Mountain, 2364 ft. 1902.
3669	(51a) Mainland, from Handa Island.	Ben Arkle and Ben Stack. 1902.
3670	(42a) Coast opposite Handa Island.	Vertical Thrust-plane in Gneiss. 1902.
3671	(59a) Handa, Sea Cliffs . .	Torridon Sandstone. 1902.
3672	(60a) Handa Island . . .	Torridon Sandstone Stack. 1902.

IRELAND.

ANTRIM.—*Photographed by* MRS. COOMÁRASWÁMY, *Walden, Worplesdon, Guildford.* 1/4.

3673	(24) Coast from Dunluce Castle towards Portrush.	Basalt filling Ancient Valley in Chalk. 1902.
3674	(23) The Gobbins Cliffs . .	Higher Lava filling crack in lower. 1902.
3675	(22) " " . .	Junction of two Lava-flows. "
3676	(21) Giant's Causeway . .	Transverse Jointing in Columnar Basalt. 1902.

Photographed by Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4.

3677	( ) Giant's Causeway . .	Spheroidal Weathering of Basalt. 1902.
3678	( ) " . .	" " " "
3679	( ) Fair Head . . .	Erratic block and *Roche Moutonnée*. "
3680	( ) Rue Bane Point . .	Camptonite Dyke. "
3681	( ) " . .	Puckered Gneiss. "
3682	( ) S. of Cushendall . .	Old Sea-caves, raised. "
3683	( ) Garron Point . . .	Slipped Basalt and Chalk. "
3684	( ) " . . .	" " "
3685	( ) Garron Point . . .	" " "
3686	( ) " . . .	" " "
3687	( ) " . . .	" " "
3688	( ) Garron Tower . . .	Standing on strip of faulted Basalt. "

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3689	( )	Garron Point, 'Leg of Mutton Rock.'	Marine undercutting.	1902.
3690	( )	Glenarm Quarry . .	Basalt overlying Chalk.	,,
3691	( )	Ballygally Head . .	Fault between Chalk and Basalt.	,,
3692	( )	Magheramorne . . .	Basalt overlying Chalk.	,,
3693	( )	,, . . .	,, ,,	,,
3694	( )	The Gobbins Cliffs . .	Amygdaloidal Basalt.	,,
3695	( )	,, ,, . .	Amygdaloidal Basalt with vertical amygdules. 1902.	
3696	( )	,, ,, . .	Tongue of Upper Lava piercing Lower vesicular Lava. 1902.	
3697	( )	Beechmount, Belfast .	Basalt Dyke in Trias. 1902.	
3698	( )	,, ,, .	,, Keuper. 1902.	
3699	( )	,, ,, .	Boulder-clay on Keuper. ,,	
3700	( )	,, ,, .	,, ,, ,,	
3701	( )	,, ,, .	Laminated Boulder-clay. ,,	
3702	( )	,, ,, .	Deceptive appearance of horizontality in Trias. 1902.	
3703	( )	Cave Hill, Belfast . .	Junction of Basalt and Chalk.	1902.
3704	( )	,, ,, . .	Basalt Dyke in Chalk.	,,
3705	( )	,, ,, . .	,, ,,	,,
3706	( )	,, ,, . .	,, ,,	,,

DOWN.—*Photographed by* Mrs. COOMÁRASWÁMY, *Walden, Worplesdon. Guildford.* 1/4.

3707	(27) Castles of Kivvitar, Mourne Mountains.	Granite, weathering.	1902.
3708	(26) Castles of Kivvitar, Mourne Mountains.	,, ,,	,,
3709	(25) Slieve Commedagh, Mourne Mountains.	,, ,,	,,

Photographed by Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4.

3710	( )	Scrabo Hill . . .	Basalt Dyke in Trias.	1902.
3711	( )	,, . . .	Basalt Dyke in Trias. Cracks filled with Calcite. 1902.	
3712	( )	,, . . .	Sills breaking across bedding.	1902.
3713	( )	,, . . .	Basalt Sills in Trias.	,,
3714	( )	,, . . .	,, ,,	,,
3715	( )	,, . . .	Basalt Dyke and Sills in Trias.	,,
3716	( )	,, . . .	Basalt Dyke cutting Trias and Basalt Sills. 1902.	

DUBLIN.—*Photographed by* W. B. WRIGHT, 14 *Hume Street, Dublin.* 1/4.

3717	(1)	Greenhills	Even and Current-bedded sand in Esker. 1902.
3718	(2)	,, ...	Ripple-bedding in Esker. 1902.
3719	(3)	,, ...	Silts in Esker; crumpled band and amid evenly bedded silt and sand. 1902.
3720	(4)	,, ...	Boulder in current-bedded sand in Esker. 1902.
3721	(5)	,, ...	Sand and silt layers truncated by coarse gravel in Esker. 1902.
3722	(6)	,, ...	Sand and silt layers in Esker. 1902.

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	KERRY.—*Photographed by* Professor S. H. REYNOLDS, *M.A.*, *F.G.S.*, *University College, Bristol.* 1/4.		
3723	(51) W. of Dunquin, Dingle	Points formed by relatively hard beds. 1900.	
3724	(52) Sight Point, Dingle	Highly inclined Smerwick Beds.	1900.
3725	(53) „ „	Rugged Old Red Sandstone.	„
3726	(54) E. side of Smerwick Harbour.	Cliff on Boulder-clay.	„
	LOUTH.—*Photographed by* Professor S. H. REYNOLDS, *M.A.*, *F.G.S.*, *University College, Bristol.* 1/4.		
3727	( ) Greenore	Basalt Sills in Carboniferous Limestone. 1902.	
3728	( ) „	Basalt Sills in Carboniferous Limestone. 1902.	
3729	( ) „	Basalt Sills in Carboniferous Limestone. 1902.	
3730	( ) „	Basalt Sills with included Gabbro fragments. 1902.	
3731	( ) Barnavave, Carlingford	Granophyre network in Gabbro.	1902.
3732	( ) „ „	„ „	„
3733	( ) „ „	Banded Gabbro.	„

Estuarine Deposits at Kirmington, Lincolnshire.—Preliminary Report of the Committee, consisting of Mr. G. W. LAMPLUGH (*Chairman*), Mr. J. W. STATHER (*Secretary*), Mr. F. W. HARMER, Mr. P. F. KENDALL, Mr. CLEMENT REID, *and* Mr. THOMAS SHEPPARD, *appointed to investigate the Estuarine deposits at Kirmington, Lincolnshire, and to consider its position with regard to the Glacial Deposits.* (*Drawn up by the Secretary.*)

YOUR Committee report that, as a favourable opportunity presented itself during the summer, preliminary operations were undertaken to investigate the beds underlying the estuarine deposit, by means of boring, and the results obtained are of such general interest that it is proposed to continue the work, and to apply for a grant of 25*l.* to enable this to be done.

While it would be premature at present to enter into a detailed account of the investigation, it may be advisable to state briefly the problems which are involved, and the results already obtained. Attention was first called to the fossiliferous nature of the deposit by Messrs. Wood and Rome on the 'Glacial and Post-glacial Structure of Lincolnshire and South-east Yorkshire,' in which they refer to it 'as a portion of the Hessle clay formation.' Mr. C. Reid gives a fuller account of the bed in his 'Survey Memoir on the Geology of Holderness' (p. 58), stating that though the sand underlying the warp probably rested directly on the chalk, the deposit was an estuarine clay of interglacial age. Mr. G. W. Lamplugh some time later made passing reference to the Kirmington section, and suggested that the bed was probably older than any of the Yorkshire glacial deposits.

The warp, which is well exposed in a brickyard, is situated on a low hill about 80 feet above sea-level. The upper portion has yielded a few species of estuarine shells, but, as our recent investigations have shown, fresh-water shells occur in a peaty bed at its base. It is proposed to investigate the fauna and flora of this bed very carefully.

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Below the warp a few feet of sand is exposed in the brickyard, but until our boring was put down there was no information as to the underlying bed. Our boring proved a thickness of 12 feet of sand and fine chalky gravel, resting on 12 feet of *stiff purple clay with foreign stones*, evidently a glacial clay, and then 11 feet of silt, sand, and fine chalk rubble, below which it was impracticable to carry the boring without tubing the hole, for which we had not the appliances.

As boulder-clay is seen at one corner of the pit to overlie the fossiliferous warp, there seems no doubt that the bed lies between two glacial deposits, but it is highly desirable that the section should be carried downward to the chalk.

The thanks of the Committee are due to Mr. J. Villiers of Beverley, who very kindly put the boring down at his own cost; also to the Earl of Yarborough (landlord), Mr. Hervey (tenant), and Mr. E. P. Hankey (agent).

Investigation of the Fauna and Flora of the Trias of the British Isles.—Report of the Committee, consisting of Professor W. A. HERDMAN (*Chairman*), Mr. J. LOMAS (*Secretary*), Professor W. W. WATTS, *and* Messrs. P. F. KENDALL, E. T. NEWTON, A. C. SEWARD, *and* W. A. E. USSHER. (*Drawn up by the Secretary.*)

[PLATES IV.–VIII.*]

THE scheme of work undertaken by the Committee includes the following:—

(1) To record all fossils from the British Trias now deposited in museums (public or private), special care being taken to get the exact locality and horizon from which the fossils were obtained.

(2) To compare the fossils from different horizons in order to see whether any changes can be traced in the character of the fauna and flora during Triassic times, and if geographical limits can be made out for certain species.

(3) To collect data regarding deep borings which show Triassic rocks.

(4) To obtain photographs of slabs showing footprints or other fossils, and of quarries and beds in which organic remains have been found.

(5) To compile a bibliography of works and papers dealing with the subject.

Considerable progress has been made as the result of the Committee's first year's work, and many offers of assistance have been received. The Committee is especially indebted to Mr. H. C. Beasley, who has furnished a report on cheirotheroid footprints, and has promised to write other reports on rhyncosauroid and chelonoid footprints next year.

REPORT ON FOOTPRINTS FROM THE TRIAS.—PART I.

Introduction.

The organic remains found in the Trias of Great Britain are so rare, and confined to so few localities, that the animal life of the period might appear to have been very limited, both in the number of species and of individuals, but for the records of the presence of an abundant fauna pre-

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served in the footprints of vertebrates and the tracks of invertebrates found in different horizons over extended areas wherever the conditions were favourable to their preservation.

The small prospects of satisfactory results, the certainty of the expenditure of much labour and time, and the necessity for the exercise of so much patience have caused the systematic study of this particular branch of palæontology to receive less attention than it deserves.

The paper of Dr. Duncan in 1828,[1] the great work of Sir W. Jardine on the Ichnology of Annandale, and the numerous papers by Huxley,[2] Owen, Egerton, Black, Mantell, Cunningham, Harkness, A. S. Woodward, and others, scattered through the transactions of various societies, are mainly concerned with describing prints found in the special localities to which the papers relate, and not to the review of the subject as a whole. Dr. T. C. Winkler,[3] in the archives of the Musée Teyler, brought together abstracts of the most important papers that had appeared up to that time, and gave a description of the examples in the museum of that institution; but he did not attempt to correlate the results.

The footprints in the Trias in England, and probably also in Scotland, are with some doubtful exceptions confined to the Keuper.[4]

Whether this indicates any great difference in the mode of deposition and prevailing conditions or not, the fact remains that from the base of the Lower Keuper to well up in the Upper Keuper footprints are met with at intervals whenever there are beds suitable for their formation and preservation.

The tracks of vertebrates are associated with those of invertebrates, probably representing Vermes, Mollusca, and Crustacea, or at any rate resembling the tracks made by recent members of these classes.

On looking through collections of Triassic footprints it will be seen that the greater number has been obtained in this country from Storeton, Runcorn, Weston, and Lymm, all in Cheshire, or in other places in the same series of exposures of the basement beds of the Keuper and those beds immediately overlying them. They have also been recorded from beds occupying a similar horizon at Grimsill in Shropshire, and in Staffordshire, both north and south, particularly from quarries a few miles north-west of Wolverhampton and from the neighbourhood of Warwick. They have also been noticed in the St. Bees Sandstone near Appleby. In Scotland the counties of Elgin and Dumfries are classical localities, and a little search would probably prove their presence in most districts where the bed of the upper division of the Trias are quarried.

The earliest finds of footprints in this country seem to have been those at Corncockle Muir in Dumfriesshire in 1824, and at Tarporley in Cheshire,

[1] 'An Account of the Tracks and Footprints of Animals found impressed on Sandstone in the Quarry of Corncockle Muir in Dumfriesshire,' by the Rev. Henry Duncan, D.D., Minister of Ruthwell, *Trans. Roy. Soc. Edin.*, vol. xi. 1828. Read January 7, 1828.

[2] Memoirs of the Geological Survey, Monograph III., by T. H. Huxley, on 'Crocodilian Remains from the Elgin Sandstone, with Remarks on the Ichnites of Cummingstone.'

[3] 'Etude Ichnologique sur les Empreintes de Pas des Animaux Fossiles,' *Archives Musée Teyler*, Harlem, second series, vol. ii., part 4, 1886.

[4] There are in Owens College Museum, Manchester, two slabs with footprints, said to have come from the Bunter Pebble Beds, near Eastham, Cheshire, and given by Sir J. Leader Williams. As a quantity of stone for use in the construction of the Manchester Ship Canal was obtained from the Runcorn and Weston Quarries there is a possibility of error as to the original source of the specimens.

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also in 1824. The former were found by Dr. Duncan and described four years later in the paper referred to above. The latter, although found in 1824, were not recognised as footprints by Sir P. Grey Egerton [1] till 1836, and were described in 1838 in a paper read at the Geological Society's meeting, December 5, and at the same meeting the prints from Storeton were described.[2]

The footprints vary greatly both in size and form, the smallest noticed being about one-eighth of an inch and the largest 15 inches in length. The variation in form is not only caused by differences in the form of the foot itself, but also by the conditions under which the tracks were made, such as the consistence of the mud, the action of the animal, whether moving rapidly or otherwise, and the inclination of the surface.[3]

The prints are generally preserved as casts on the under surface of the overlying sandstone. The bed of marl on which the original prints were made, being very thin and friable, is seldom fit for removal. Immediately after a slab is lifted the perfect prints are often visible, but rapidly become obliterated. At Corncockle Muir, however, the prints themselves are frequently preserved.

The bed of marl is often much broken up by desiccation cracks and otherwise deformed in drying, which greatly interferes with the preservation of impressions, and casts of these cracks often form a network of ridges on the overlying sandstone.

The beds in which the prints were made appear to have resulted from temporary accumulations of water, which, as they disappeared, left behind the mud, on which were preserved the footprints of whatever animals happened to cross it. In the loose sand which formed the general surface of the country such records of their presence would not be preserved.

There is no indication in the forms preserved that they were produced by water-loving animals; there is no more reason for supposing that the mud attracted an unusual concourse of animals than that it merely recorded the presence of the usual inhabitants.

There is every probability that the sand was usually deposited on the mud by æolian rather than by aqueous agency. The prints were often made in a very thin layer of mud (occasionally so thin that it adhered to the foot of the animal, leaving the underlying sand exposed), and this thin layer in drying was broken up by shrinkage and divided into a number of curved plates, the curved surfaces being perfectly reproduced on the under surface of the layer of sandstone above. Had this mud been again covered with water it would have lost its curvature, and the

[1] 'On two Casts of Impressions of the Hind Foot of a gigantic Cheirotherium from the New Red Sandstone of Cheshire,' by Sir P. Grey Egerton, *Proc. Geol. Soc.*, vol. iii. p. 14. Read December 5, 1838.

[2] 'An Account of the Cheirotherium and other unknown Animals lately discovered in the Quarries of Storeton Hill, in the Peninsula of Wirrall, between the Mersey and the Dee,' *Proc. Geol. Soc.*, vol. iii. p. 12. Read December 5, 1838. This appears to have been a report by the Liverpool Natural History Society written by Mr. J. Cunningham and submitted by the Geological Society in London.

[3] A letter from Professor Buckland, dated Oxford, December 12, 1827, quoted in Dr. Duncan's paper referred to above, shows how fully the importance of studying the effect of varying conditions on the prints left by recent animals was recognised by earlier investigators.

Professor T. McKenna Hughes in the *Quarterly Journal Geological Society*, vol. xl. p. 178, pls. 7–11, has a paper on 'Some Tracks of Terrestrial and Freshwater Animals,' which, though referring to the tracks of invertebrates, has an important bearing on the present subject.

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overlying sandstone would have been flat on its under surface, as has been shown by Messrs. Davies and Reade.[1]

Again, we could hardly expect to find the sharpness of the prints to be so well preserved had they been subjected to the erosive action of water moving with sufficient rapidity to carry fairly coarse sand.

There are, however, some few cases in which the sand would appear to have been deposited by water, where the casts of the prints consist of laminæ of rather micaceous sandstone. An example of this may be seen in the collection at University College, Liverpool. Such prints are very imperfect.

Occasionally prints are met with on rippled surfaces with the ripples extending across the prints. An example of this may be seen in a large rippled slab at the Liverpool Public Museum, where the ripple marks are distinctly traceable across some large imperfect prints; but a long series of smaller prints crossing these seem to have been made subsequently to the rippling. There is also one large print from Storeton in the University College, Liverpool, collection distinctly showing the same thing. In these cases the larger prints may have been made whilst there was a thin layer of water over the mud, just sufficient to form the short ripples represented. Such rippled surfaces are usually free from desiccation cracks, and the wind-borne sand may have been deposited before the water had quite disappeared. The drying would in that case be very gradual, and the curvature of the layer by the very unequal rate of desiccation of the upper and lower surfaces would be prevented. The covering of the mud by wind-borne sand whilst it still retained its moisture will explain the absence of cracks on some surfaces, and their presence in others where the thickness of the beds of marl is the same.

Character of the Beds in which Footprints occur.

Cheshire.—The quarries at *Storeton* are in the Lower Keuper Sandstone. It is here brought down by a trough fault into the Upper Bunter, which bounds it on the east and west, and so forms the ridge that runs approximately north and south from Oxton to Higher Bebington.

The point now being worked, and where footprints are obtained, is at the northern end of the south quarry, and the working shows a vertical face of 120 feet. The footprint beds occur rather above the middle of the face, and just there are three in number, confined within a thickness of 3 or 4 feet. They were estimated by Mr. Morton[2] to be about 124 feet above the base of the Keuper. The stone obtained is a fine grained sandstone, white or cream-coloured, with occasionally more deeply iron-stained surfaces. There are a few beds of very red marl from an inch to some feet in thickness, and thinner beds of a fine white clay. In the stratum containing the footprint beds the sandstone is flaggy, but the rest is rather massive and compact, somewhat soft towards the top, harder below, the best stone being obtained below the footprint bed.

The method of working is to clear a space of 30 or 40 feet square and work downwards, so that the surface of the footprint beds is only exposed occasionally and its extent limited. It is hoped that careful observations may be continued in order to ascertain whether some slight differences that have been noticed in the footprints from the three beds are really characteristic of the three beds over a larger area.

[1] 'Description of the Strata exposed during the Construction of the Seacombe Branch of the Wirral Railway,' *Proc. Liverpool Geol. Soc.*, vol. vii. p. 329.

[2] *Geology of the Country around Liverpool*, 2nd edit., p. 106.

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The beds of white clay in which the prints were made are so thin as to be hardly discernible on the freshly worked face, but become readily traceable, after a few years' weathering, when a scant vegetation has taken root in the softer places.

The quarries in the neighbourhood of *Runcorn* extend about a mile along the escarpment of Lower Keuper, forming the crest of the hills facing the estuary of the Mersey from Runcorn to Weston.

The sandstone is of coarser grain than at Storeton, and of a dull red colour; but the position and nature of the footprint bed are about the same, and it can be traced the whole length of the hill until it passes beneath the floor of the principal quarry now worked. The spoil banks covering the larger area of the old quarries still yield numerous examples, and in spite of the coarse nature of the stone and the deformation of its surface by desiccation, cracks, &c. some very perfect specimens have been preserved. While the larger forms are less plentiful than at Storeton, the smaller ones are more numerous and varied.

There is a second bed, a considerable distance below the footprint bed, which yields very many curious markings, but none that can be said with certainty to be of organic origin.

At *Lymm* the quarries in the neighbourhood are mostly closed, and the spoil banks covered with vegetation.

Near *Tarporley* and in *Delamere Forest* beds which have yielded footprints are found. They occur at horizons rather higher in the Keuper than those at Storeton and Runcorn.

Shropshire.—The quarries at *Grimsill*, Shropshire (easily reached from Yorton station on the Crewe and Shrewsbury Railway), are very extensively worked, and yield from time to time not only numerous footprints but remains of rhynchosaurus.

They are very like the quarries at Storeton both in the character of the stone and the position of the beds.

Warwickshire.—Near Warwick the quarries at the *Coten End* in the Lower Keuper are not much worked now. The small but very interesting quarry at *Shrewly*, a mile or so from Hatton Junction, on the Great Western line, is in the Upper Keuper Sandstones, with the marls above and below. Footprints are frequently found, and the remains of invertebrates.

Staffordshire.—Traces of footprints have been noticed in quarries at Alton and Hollington, in North Staffordshire, in the building stones of the Lower Keuper.

In South Staffordshire footprints are very numerous in the quarries along the outcrop of the harder beds of the Keuper a few miles north-west of Wolverhampton. Some of the sections have recently been described by Mr. Beeby Thompson, F.G.S.[1]

Scotland.—The footprint-yielding quarries in Dumfriesshire do not seem to be much worked now; the footprint beds are described as extending through a thickness of about forty-five feet (see Dr. Duncan's paper referred to above).

For an account of the quarries at Elgin see Huxley's monograph, previously referred to; also 'Reptiliferous Sandstones of Elgin,' by Rev. George Gordon, LL.D., 'Trans. Geological Society Edinburgh,' February 1892.

[1] 'Some Trias Sections in South Staffordshire,' by Beeby Thompson, F.G.S., *Geol. Mag.*, Dec. iv., vol. ix., May 1902.

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Description of the Footprints.

In describing the footprints in detail it will be convenient to consider them merely as footprints, regarding only the features they individually present, without reference to the animal that may be supposed to have made them, except in the case where two forms have frequently been found together in such a position as would warrant our considering them as representing the fore and hind feet of the same animal.

If we bear this principle in mind and fully recognise that the nomenclature [1] does not involve any assumption as to their origin, it will be well to group together certain of them as cheirotheroid, rhynchosauroid, and chelonoid, the prints in each group having a certain resemblance to those ascribed by the earlier writers to the Cheirotherium, the Rhynchosaurus, and 'some Chelonian' respectively. This will be the more convenient, as the forms in each group differ greatly from those in either of the others. There will remain many other forms that cannot be included in these groups, but they may be considered later, the above being taken first, as they contain the more common forms.

Cheirotheroid Forms.

The most striking of the footprints found in the Triassic rocks is that to which Professor Kaup gave the name 'Cheirotherium' when it was discovered at Hessburg, near Hildburghausen, in 1835. He also suggested the alternative name of 'Cheirosaurus' in the event of the animal whose presence it recorded proving to be a saurian. As we are still ignorant of the nature of the animal referred to it will be well to adhere to the original name.

The print is pentadactylate and roughly resembles a human hand. It varies from 5 to 15 inches in length, the average being from 8 to 9 inches.

The middle digit is the longest, those next on either side being rather shorter, and the outer ones considerably shorter still.

The divisions between the outer digits and those next them extend farther back than those on either side the middle digit.

Four of the digits are only slightly divergent, and each shows the presence of a sharp claw at the extremity. The outer digit on one side has its origin further back than the corresponding digit on the other side, is broader in proportion to its length, diverges considerably from the axis of the rest of the foot, and is usually curved outwards: it does not show any trace of a claw.

Where a series of prints is shown it is usually found that they are in a single line, and that the curved digit occurs alternately on the right and left side. If a line be drawn through the middle digits of the prints having the curved digits on the one side and the corresponding digit of those having the curved digit on the other, it will be found that the distance between the two lines is seldom over 3 inches. This would point to the curved digit being the fifth; but the suggestion has been made that the animal may have crossed its feet to the extent of 3 inches, and that the curved digit was the first. However, tracks have been found where the distance between the lines of the right and left feet is much greater. There is a slab in the Warrington Museum from Lymm where the lines are fully 6 inches apart, and another in the British Museum, No. R. 728,

[1] In the detailed description which follows the various forms have been indicated by letters. These correspond with the nomenclature adopted in my previous papers, *Proc. Liverpool. Geol. Soc.*, vol. vii. p. 391; vol. viii. p. 238; vol. ix. pp. 81 and 238.

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from Hildburghausen, very similar, in both of which the curved digit is still the outer one. It is therefore clear that it represents the fifth or outer digit, and for the purposes of this report will be described as such.

At the base of each digit there appears to be a pad or cushion, often merging into that of the next digit; that at the base of the fifth digit is larger than the others and quite separate from them, and it forms the posterior outer margin of the print; but on the inner side the margin of the print is very slightly marked, sometimes not at all, between the pad at the base of the first digit and that of the fifth.

Occasionally the fifth digit is not curved, and is only slightly divergent from the other digits. Two prints from Grimsill, Salop, show this peculiarity: one is in the Ludlow Museum and the other at Shrewsbury.

A short distance in front of the prints just described indications are found of the presence of a smaller foot. The print is frequently very slight, but is sometimes very clearly defined, and its axis coincides with that of the larger print.

It consists of five short divergent digits, the fifth being nearly at right angles with the third; there is no clear indication of an ungual termination; the print is rather broader than long, and varies from a third to half the size of larger print, which we may consider as that of the pes, and the smaller as the manus. There are pads at the base of the digits which coalesce and form the posterior margin of the print.

The weight of the body was principally borne by the pes, as, although presenting a much larger surface than the manus, it made a deeper impression.

Both pes and manus seem to have been almost digitigrade, the distal extremities only of the metatarsals and metacarpals reaching the ground: these being represented by the pads at the base of the digits.

Traces of a Caudal Appendage.

No certain traces of a tail have been seen associated with these footprints. In the British Museum there is a slab of prints from Storeton,[1] R. 730, on which is a long tapering mark, with rows of scales on the thicker part and terminating in some indistinct rod-like markings. This, it has been suggested, may indicate the presence of a tail. Very similar markings are present on a large slab from Lymm, in the Warwick Museum. In neither case does the marking in question occupy the position in regard to the footprints that might have been expected, and it is possible the marks in question may have had a vegetable origin. Undoubted tail-marks have been observed, but they were not associated with the Cheirotherium footprints. As will be seen later, a small print bearing some resemblance to the Cheirotherium does show the presence of a tail, and there is a very clear track of a tail associated with some webbed footprints on a slab at Warwick.

Traces of the Integument.

Professor W. C. Williamson[2] recorded and figured a print from Daresbury, a few miles from Runcorn, which showed the presence of small scales covering the sole of the foot. He says:—'Many of them (the scales) run across the foot in oblique lines, thus leaving no doubt they

[1] Described and figured in *Geology of Country around Liverpool*, Append., p. 300.

[2] 'Cheirotherium Footprint from the Base of the Keuper Sandstone, Daresbury, by Professor W. C. Williamson, *Quart. Journ. Geol. Soc.*, vol. xxiii. 1867, p. 56.

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represent true scales and not irregular tubercles as are seen on the skin of many batrachians. The scales on the toes and anterior part of the foot are smaller than on the posterior.' Several footprints from Storeton are similarly, though not so distinctly, marked, and Mr. Beeby Thompson has found an example [1] from South Staffordshire. The markings very much resemble the scales on the feet of recent crocodilia.

The Cheirotherium footprints show considerable variation, even in the same quarry; but it is generally such as might arise from the age of the individual making the print. Some prints, for instance, suggest a large fleshy foot, with the nails but faintly shown; others are more slender, with the details more distinct. There are, however, forms showing more important variations, with the same distinctive features frequently recurring.

A 1. ½.—Left Pes and Manus.

A 1.—The most common form is that figured by Mr. G. H. Morton [2] as representing

Cheirotherium stortonense.
Cheirosaurus stortonensis.

In addition to the pads at the base of the digits this form shows similar pads on the digits themselves, presenting gently rounded surfaces divided by slight constrictions which probably mark the position of the joints of the phalanges. The prints of the digits are broadest about the middle and narrow towards the base. (Plate IV.)

The natural cast figured by Mr. Morton is in the British Museum (R. 2591), and measures 9 inches in length. A slab with a series of three hind feet is in the Bootle Museum,[3] and is supposed to be one of those referred to by Mr. Cunningham in his original paper. The feet correspond in size and form to those figured by Mr. Morton. The distance between the print of the left foot and the next print of the same foot is a little over 3 feet 7 inches, and the distance between the centre of the right foot and a line joining the centres of the two prints of the left is less than 3 inches.

The somewhat elongated posterior portion of the print in Mr. Morton's specimen is very possibly caused by the foot having moved slightly forward after being put down; there is some indication of the mud having been slightly raised in front of the print, but at any rate this elongation is not common in the Storeton prints.

The impressions of the pads on the digits are so imperfectly and irregularly preserved that, supposing they coincide with the phalanges, the number of these in each digit of the pes cannot be determined with the certainty that is desirable. So far as has at present been observed the formula would be $\frac{\text{I.}}{2}\ \frac{\text{II.}}{3}\ \frac{\text{III.}}{3}\ \frac{\text{IV.}}{3}\ \frac{\text{V.}}{2}$. As there are no clearly marked

[1] Described and a portion figured in *Geol. Mag.* for May 1902. 'Footprints from the Keuper of South Staffordshire,' A. S. Woodward, LL.D., F.R.S., &c.

[2] *Geology of Country around Liverpool*, pls. 8 and 9.

Mr. Morton suggested the specific name 'Stortonense' in a paper read March 17, 1863, *Proc. Liverpool Geol. Soc.*, vol. i.

[3] The fifth digit of the middle print of this series has been chipped, giving a different form from that of the other two. This is not shown in a drawing made about 1839, so the damage is probably subsequent to that date.

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Slab of sandstone, probably from Storeton, with two series of footprints of A1 in relief. Owens College Museum, Manchester.

Illustrating the Report on the Investigation of the Fauna and Flora of the Trias of the British Isles.

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Natural Cast of A2 from Storeton. British Museum, Natural History. R414.

Illustrating the Report on the Investigation of the Fauna and Flora of the Trias of the British Isles.

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pads on the fifth digit, the number of joints has been estimated from its curvature.

The pads, if there are any on the manus, are too slightly marked to guide us in making any formula for that foot. The manus, whenever at all clearly shown, shows distinctly that it was pentadactylate like the pes.

The larger and stouter prints from Storeton appear practically identical with those from Hildburghausen, to which the name Cheirotherium was originally given.

A 2.—A form differing somewhat from the typical *Cheirotherium stortonense* is found occasionally at Storeton, but more frequently in the Lymm district. The print is broader than A 1, and the digits are rather shorter in proportion to the length of the foot, and are widest at the base, where their width slightly exceeds that of the middle of the *Cheirotherium stortonense*. They taper rapidly to their extremities, which show the presence of nails.

A 2. ⅛.—Left Pes.

The sole of each of these digits, instead of presenting a gently rounded surface, rises sharply from each side towards the middle line, forming there a slight ridge. There are no indications of pads on the digits, but those at their base are clearly marked.

The first and fifth digits are both much shorter in proportion to the others. The fifth, whilst projecting outwards at a considerable angle, has not the curvature so characteristic of *Cheirotherium stortonense*, neither does it nor its pad form so conspicuous a feature.

The size of the foot is generally about the same as *Cheirotherium stortonense*. (Plate V.)

The manus in the few specimens seen would seem to be rather broader and the digits rather stouter and more divergent than in *Cheirotherium stortonense*; possibly these are only individual peculiarities.

A 3. ⅛.—Left Pes.

A 3 is represented by the form found at Tarporley, Cheshire, and described by Sir P. Grey Egerton[1] under the name *Cheirotherium Herculis* from the specimens now in the British Museum (R. 295): in many respects this resembles A 2; but besides being much larger—about 15 inches in length—it is much elongated and the digits are shorter in proportion to the whole length. No impression of the manus has been recorded as associated with it. (Plate VI.)

The possibility of the appearance of the first four digits in A 2 and 3 being due to the condition of the mud in which the prints were made and that such conditions might be more frequent in the Lymm district or the horizon in which these prints have been found, has not been overlooked; but as the digits of this form are associated with a much smaller

[1] 'On two Casts in Sandstone of the Impressions of a gigantic Cheirotherium from the New Red Sandstone of Cheshire, *Proc. Geol. Soc.*, vol. iii. p. 14, and 'Notes on Type Specimen of *Cheirotherium Herculis* (Egerton),' H. C. Beasley, *Proc. Liverpool Geol. Soc.*, vol. ix. p. 81, pl. 5, March 12, 1901.

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fifth digit it seems we are justified in considering the difference as structural.

The three forms described may be provisionally grouped under letter A :—

A 1. *Cheirotherium stortonense.*
A 2. The Lymm form.
A 3. *Cheirotherium Herculis.*

K.—The next form to be considered is one that would seem at first sight to be altogether dissimilar to the foregoing, but is possibly very intimately connected with them : it is a short round print, rather broader than long, and measures about 5 inches across. It shows four toes, greatly resembling the first four of A 2, and, like them wide at the base and tapering rapidly to a point without trace of pads, except at the base, and presenting the longitudinally ridged appearance described. The other digits are somewhat curved laterally, and a similar curvature is observable in the *Cheirotherium Herculis.*

K. ⅛.—Left Pes.

It has been found at Storeton, but is more common in the Lymm district. There are two examples from Lymm in the Grosvenor Museum, Cheshire.

This corresponds, in fact, somewhat to the distal portion of A 2, the fifth digit not having apparently reached the ground, or at any rate not having left an impression. However, as there is no sign of its being a merely imperfect print, it has been described separately as K.[1]

B 1 is a small form described and figured by Mr. G. H. Morton [2] from a specimen in the Liverpool Free Museum from Storeton. It consists of four stout rapidly tapering digits, slightly divergent, and a fifth short and broad standing outwards at a considerable angle. The points of difference between A 1 and A 2 are greatly accentuated, the breadth of the digits being much greater and the length less in proportion to the size of the print. Mr. Morton has named this *Cheirotherium minus.* It is doubtful whether it is the same as the print to which Sickler gave that name in 1835 ; but no opportunity has occurred for comparison. The small print in the British Museum, R. 419, supposed by Lydekker [3] to represent this, is rather obscure, but seems to differ from the Liverpool print. The length of the print is nearly 3 inches, but the writer has one about half the size—also from Storeton—in which the peculiar features of the print are more strongly marked. This may possibly point to the prints being made by an immature animal, as suggested on the original label in the Liverpool Museum. This print will be referred to as B 1.

B 1. ¼.—Left Pes.

B 2. There is some resemblance between the form just described and the prints on a slab in the Bootle Museum (No. 5) showing a series of five prints, with a slightly sinuous furrow following the middle line, ap-

[1] 'On two Footprints from the Lower Keuper and their Relation to Cheirotherium Stortonense,' *Proc. Liverpool Geol. Soc.*, vol. ix. p. 238, pl. 15.
[2] *Geology of the Country around Liverpool*, Append., p. 299.
[3] *Catalogue of Fossil Reptilia in British Museum*, vol. iv. p. 217.

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Natural casts of two prints A3. Cheirotherium Herculis, Egerton.
British Museum, Natural History.

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Part of a slab of sandstone from Storeton, with prints in relief of a series of A1, crossed obliquely by another series of smaller prints of L. British Museum, Natural History. The whole slab measures about 7 feet 6 inches in length; only about half of the length is shown in the Plate.

Illustrating the Report on the Investigation of the Fauna and Flora of the Trias of the British Isles.

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parently caused by a tail. This is almost certainly the slab described by Mr. Cunningham[1] as having been found at Flaybrick Hill, Birkenhead (it is labelled 'Probably Runcorn' at present). There are two prints of the right foot and three of left, 6 inches separating the right line from the left; length of stride from one print to the next of the same foot is 15 inches. The prints are 1½ inch long, and are rather more slender than B 1; both the first and fifth digits diverge considerably from the others; there is no curvature discernible on the fifth; the pes appears to have been placed upon the print of the manus, obliterating it and confusing both; but one of the prints is fairly clear and was figured. Other imperfect prints probably representing this have been seen, but at present we have no knowledge of the manus. This form will be described as B 2.[2]

B 2. ½.—Left Pes.

L.—One other form must be included in this group. It is a small form about 4 inches in length, and resembles Cheirotherium in every respect except that it presents only four digits. Three are long, straight, and nearly parallel, the middle one the longest, and all terminating in long claws, and a fifth, somewhat curved, occupying nearly the same position as the fifth in A; but it is rather further back and slightly nearer the middle line of the foot.

L. ½.—Left Pes and Manus.

The pads at the base of the digits are well marked. The digits represented are probably 2, 3, 4, and 5. The curve on the fifth digit is almost entirely confined to the bending of the last joint. The most perfect specimen seen is from Guyscliff, Warwick, now in the Bootle Museum. In it there is a very clearly defined margin on the inner side of the print extending from the tip of the second digit to the posterior margin of the pad, with no trace of a first digit reaching the ground. The same form has been found at Storeton lately, and there is in the British Museum a long slab of Cheirotherium prints (R. 729) on which a series of these prints cross the others obliquely. In these the prints of the manus (not shown on the other examples) is seen. It consists of three short stout digits, and is three-quarters of an inch in length and about the same in breadth. (Plate VII.)

This form has been described under the letter L.[3]

This print seems to agree in some respects with the description given of *Cheirotherium minus* (Sickler) in Lydekker's 'Catalogue of Fossil Reptilia and Amphibia in the British Museum,' vol. iv. p. 217, which is apparently taken from Sickler, but it does not agree with that figured by Winkler (see *ante*).[4]

The foregoing have all been seen to have a form resembling the Cheirotherium print and readily take their places in this group; and

[1] *Proc. Liverpool Lit. and Phil. Soc.*, vol. i. (figure).

[2] In the Musée Teyler, Harlem, there is a print described and figured by Winkler as *Cheirotherium minor*. M. Sickler (*Archives*, vol. ii. p. 430, pl. 3, fig. 2). He suggests it may be the print of a young animal, but the figure does not agree with the prints discussed above.

[3] *Proc. Liverpool Geol. Soc.*, vol. ix. p. 289, pl. 15.

[4] See also Buckland's *Bridgwater Treatise*, 1st edit., vol. i. p. 265, and vol. ii, pl. 26.

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although in two cases only four digits are represented, the foot was probably pentadactylate; in the case of K, the fifth digit, and in L the first digit failing to reach the ground, or at any rate not leaving any trace of its having done so. Whether this may or may not be due to a gradual shortening of the outer toes and the development of a form with only three functional digits is a matter worth considering. For this reason it may be well to notice here a form that can hardly be considered cheirotheroid, nor can it well be classed in either of the other groups. It is a three-toed form found in the dolomitic conglomerate of Glamorganshire and described by Mr. W. J. Sollas[1] under the name of *Brontozoum Thomasi*. There are three impressions of the left foot and two of the right. The footprint 'shows the mark of three toes diverging from a posterior heel; the middle toe is the most regularly defined, the outer comes next in regularity, and the inner last.' 'The outer toe is confluent with the heel; the middle and inner toes are separated from it and from each other.' The total length of the impression from the point of the nail of the middle toe to the back of the heel is 10 inches; the angle contained between the inner and outer toes is 50°, and the projection of the middle toe beyond a line joining the points of the inner and outer toes is 3½ inches. The middle toe shows the existence of a nail, which is not so clearly shown on the others. The length of stride is 3 feet 2 inches. The slab is now in the Cardiff Museum. Owing to the generally unsuitable nature of the matrix impressions would have been seldom made and still less frequently preserved. (Plate VIII.)

In connection with the subject of this report the writer had occasion to examine the footprints of the following museums:—British Museum, Natural History; Museum of the Geological Survey; Liverpool, Free Museum; Liverpool, University College Museum; Bootle (Lancashire), Free Museum; Manchester, Owens College Museum; Salford, Peel Park Museum; Warrington, Municipal Museum; Chester, Grosvenor Museum; Shrewsbury, Free Museum; Warwick, Naturalists and Archæologists' Field Club Museum; Cambridge, Woodwardian Museum; Ludlow Museum; and he has to thank those in charge of these collections for the facilities and assistance afforded him, particularly Dr. A. S. Woodward, F.R.S., Mr. E. T. Newton, F.R.S., F.G.S., &c., and Dr. C. W. Andrews for advice and assistance.

Unfortunately the time at the writer's disposal has not been sufficient to enable him to do more this year than give an account of one group of footprints; but should the Committee be reappointed, and see fit to allow him to continue the report, he hopes to describe the remaining two groups and such other footprints as have come under his notice in time for the succeeding meeting of the Association.

[1] 'On some Three-toed Footprints from the Triassic Conglomerate of S. Wales,' by Mr. W. J. Sollas, M.A., F.G.S., *Quart. Journ. Geol. Soc.*, vol. xxxv. p. 511. Read April 9, 1879.

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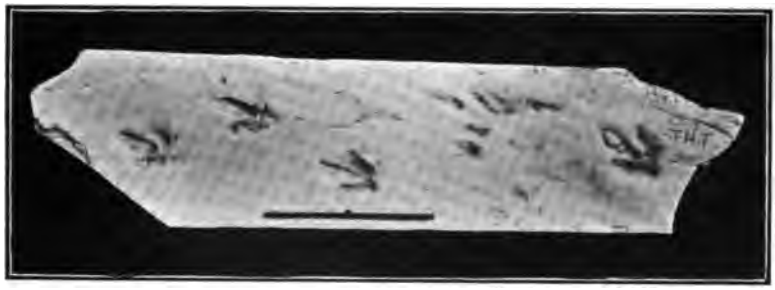

Footprints from the Triassic Conglomerate of Newton Nottage, Glamorgan. Cardiff Museum.

Illustrating the Report on the Investigation of the Fauna and Flora of the Trias of the British Isles.

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Erratic Blocks of the British Isles.—Eighth Report of the Committee consisting of Dr. J. E. MARR (*Chairman*), Mr. P. F. KENDALL (*Secretary*), Professor T. G. BONNEY, Mr. C. E. DE RANCE, Professor W. J. SOLLAS, Mr. R. H. TIDDEMAN, Rev. S. N. HARRISON, Dr. J. HORNE, Mr. F. M. BURTON, Mr. J. LOMAS, Mr. A. R. DWERRYHOUSE, Mr. J. W. STATHER, Mr. W. T. TUCKER, *and* Mr. F. W. HARMER, *appointed to investigate the Erratic Blocks of the British Isles and to take measures for their preservation.* (*Drawn up by the Secretary.*)

THE majority of the records received during the present year has been contributed by workers in Yorkshire, and it is satisfactory to note that one of the few areas in that county inadequately studied hitherto is now receiving attention. The Thirsk Naturalists' Club has organised a sub-committee acting in co-operation with the Yorkshire Boulder Committee, and the first results of its investigations in the Vale of Mowbray are now presented. The present writer visited Thirsk in the spring of this year and identified many boulders which will serve as types for the guidance of the local workers. The observations made in the Vale of Mowbray may be said to close up the last gap in the network of observations which now extends over the whole of the great county of York from the Tees on the north to Sheffield on the south, and from Ingleton on the west to the sea. The thoroughness with which the search for erratics has been made is very gratifying, yet the fact that fresh types of erratics still continue to be recorded shows that this well-worked field is far from being exhausted.

In the present report we record the recognition by Professor Brögger of yet another type of igneous rock derived from the prolific country near Christiania, and the visit of the Yorkshire geologists to the Tweed Valley, referred to in the report presented last year, has borne fruit in the identification at two localities in Yorkshire of examples of the trachytes so characteristic of the south-east of Scotland. Other boulders worthy of mention are the small boulder of Borrowdale Ash, found by Mr. Gregory, near Keighley, at an altitude of 900 feet O.D. This is an interesting confirmation of a record to be found in the report for the year 1875. Mr. Hemingway sends some valuable notes on the puzzling drift-area about Barnsley.

A welcome contribution to the knowledge of a little known area is the report on boulders in co. Durham sent by the Rev. W. J. Wingate.

A series of records from East Anglia (including the first sent to this Committee from the county of Norfolk) shows that valuable results would repay workers in the district; and it should be pointed out that with the centralisation of the brickmaking industry at a few centres, and the general introduction of road-metal from distant places, the opportunities for observation are being rapidly diminished by the closure of brickyards and gravel-pits which furnish at present the most numerous and convenient opportunities for the study of erratics, especially the smaller ones, at the same time the larger boulders are being broken up for road-mending. It should here be again pointed out that the smaller stones are frequently of greater interest than large ones. Some of the

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most interesting erratics yet recorded in England, such as the Norwegian rhomb-porphyries and the Riebeckite-Eurite of Ailsa Craig, have never been found in large blocks, and usually are little more than pebbles.

The most conspicuous boulders in East Anglia are the dolerites and basalts, which are by far the most numerous of the igneous boulders, large or small; and the writer is convinced that the determination of their places of origin would throw much light upon the difficult problems of East Anglian glacial geology. Over a wide area from the east coast of Norfolk to the Fens, and southward into Essex and Hertfordshire, boulders of sandstone are very numerous: some of these, especially in Norfolk, are derived from the Neocomian sandstone, while in the southern part of the area blocks of brown sandstone are of very common occurrence, which are for the most part of Tertiary age; but whether all are from the same source or not requires investigation.

The discovery of rhomb-porphyry is not an absolutely new fact in the geology of Norfolk, but the specimens recorded from Hellesdon and Wymondham are interesting, as they are the most southerly stations known for this rock in Britain.

The two examples of Laurvikite at Bacton and Happisburgh respectively are the first records of this rock south of Lincolnshire. An endeavour has been made to secure the Bacton specimen for the Norwich Museum.

The present writer has long felt the need for some summary presentment of the vast mass of facts accumulated by this Committee and its predecessor during the last thirty-two years, and he has therefore prepared a synopsis of the whole of the reports from the year 1873 down to and including the present one. The labour has been great, but the advantage and convenience to students of glacial geology will, he hopes, be more than commensurate. The records for Ireland have not been included in this summary, as they were presented in tabular form in the Report for 1902. Next year it is contemplated to publish a second part of this synopsis, in which the distribution of boulders of noteworthy rocks will be analysed.

DURHAM.

Communicated by the Rev. W. J. WINGATE, *of Bishop Auckland.*

Blackhalls (shore at)—

Granite (probably Dumfries), porphyrite (Cheviot type), augen-gneiss, gneiss, quartz porphyry.

Bishop Auckland Cemetery (in boulder clay)—

Carboniferous limestone.

Barnard Castle (in bed of R. Tees)—

Whin Sill, Carboniferous sandstone, andesitic ash (Lake District)

Harperley (in bed of R. Wear)—

Volcanic breccia (? Lake District).

Piercebridge, 'The Greystone' Boulder—

Andesitic breccia (Lake District).

Oxenlow—

Andesite (Lake District)

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Lindisfarne—

Andesitic ash (Lake District).

WESTMORELAND.

Reported by Mr. PERCY F. KENDALL.

Brackenber Moor, Hilton—

Shap granite.

Milburn, E. of Howgill Castle—

Whin Sill, Carboniferous limestone and sandstone.

Burney Hill, near Milburn—

Whin Sill, Carboniferous sandstone.

Hazelrig, near Gamblesby—

Carboniferous basement conglomerate, granite (Galloway), red lamprophyre resembling that of Knock Pike, Shap granite, Dalbeattie granite, Whin Sill.

YORKSHIRE.

Communicated by the Yorkshire Boulder Committee.

Reported by Mr. W. CHADWICK.

Thirkle Bridge, Holderness—

Dolerite, 36 inches by 31 inches by 32 inches. Situated ¼ mile south of the bridge.

Reported by Mr. W. H. CROFTS.

Hornsea—

Millstone grit.

Reported by Mr. P. F. KENDALL, *F.G.S.*

Burstwick—

Trachyte similar to that of Eildon Hills, Melrose; dolerite similar to those of Black Hills, near Earlstown; quartz porphyry.

Bridlington (from beach)—

Trachyte, south of Scotland.

Reported by Mr. G. W. B. MACTURK.

Little Weighton—

In chalky dry valley deposit near Dannatt's chalk quarry, containing pebbles of basalt, quartzite, and sandstone.

Newbald.—On roadside between Bushey Hill and Little Wood Plantation, about 2½ miles east of Newbald, 372 feet above O.D.

Dolerite, 54 inches by 36 inches by 24 inches. Probably removed from an adjacent field.

Reported by Mr. THOS. SHEPPARD, *F.G.S.*

Brough.—The boulder of augite-syenite recorded from Mill Hill gravel pit in the 1899 Report has been transferred to the Hull Museum.

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Kelsey Hill—

Carboniferous limestone, 57 inches by 41 inches by 29 inches. Found during excavation of gravel 15 feet below the surface. Now at Hull Museum.

Aldbrough (Holderness)—

A large mammoth tooth weighing 11 lb.

Sand-le-Mere—

Small mammoth tooth found on beach.

Reported by Mr. J. W. Stather, *F.G.S.*

Hornsea—

Small boulder of keuper marl with pseudomorphs of salt crystals.

Reported by Mr. F. F. Walton, *F.G.S.*

Hornsea—

Coarse red granite, 42 in. by 30 in. by 24 in.
Augen-gneiss, 24 in. by 24 in. by 20 in.
Dalbeattie granite, 12 in. by 6 in. by 5 in.

Reported by Messrs. H. B. Muff, *B.A.*, *F.G.S.*, *and* Percy F. Kendall, *F.G.S.*

Stonegate, Eskdale.—In railway cutting above Stonegate—

Syenitic dyke-rock.

Professor W. C. Brögger, of Christiania, has seen this specimen, and writes:—'This rock is without doubt originally transported from the Christiania region. It is a syenitic dyke-rock, consisting of micro-perthite and katophoric hornblende, with traces of riebeckite, further with titanite, magnetite, &c. Such dyke-rocks occur as well in the Longen Valley as north from Christiania accompanying pulaskites and nordmarkites.'

Reported by Mr. H. Brantwood Muff, *B.A.*, *F.G.S.*

Linton, Wharfedale—

Silurian slate. At the S. end of the railway cutting, one-third of a mile W.S.W. of Linton, four large boulders of cleaved greenish Silurian slate in boulder clay. The largest boulder is nearly 8 ft. long; another is striated from N.W. to S.E.

Reported by Mr. E. Hawkesworth.

Flaxby, S. of Boroughbridge, in Moraine-ridge—

Whin sill.

Wykeham—

Whin sill.

Brompton, near Northallerton—

Andesite (Borrowdale series).

Wighill, near Tadcaster—

Whin sill.

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Reported by the Thirsk Naturalists' Club, per Mr. J. E. Hall, *Secretary.*

Thirsk.—In gravel pit—

Gabbro (Carrock Fell), porphyrite (Cheviot type), Shap granite, oolite (not local), Carboniferous conglomerate (Roman Fell type), granite.

Upsal, Wool Moor, 725 feet O.D.—

Dolerite, millstone grit, black limestone.

Upsal, Hag's Hill, 225 feet O.D.—

Gabbro (Carrock Fell).
Granite (? Cheviot).

A. Very frequent throughout district.

Carboniferous limestone, black and encrinital.
Ganister.
Chert.
Millstone grit.
Dolerite.

B. Fairly frequent throughout district.

Andesitic breccia.
Cleaved andesitic breccia.
" " ash.
" " " with epidote.
" " rhyolitic breccia.
" " agglomerates.
" " purple breccia.
Shap granite.
Vein quartz.

C. Occasional.

Cheviot porphyrite.
Carboniferous conglomerate.
Volcanic tuff (? Cheviot).
Gabbro (? Carrock Fell).

Remarks.—Dividing our district into three longitudinal strips, roughly, Codbeck (central), Swale (western), edge of Hambletons (eastern), we find Class *A* pretty evenly distributed.

Class *B* very frequent in the central district and only occasional in the E. and W.

Class *C*, so far as our research goes, are almost entirely confined to the central district.

Gravel Pits, Thirsk—

Cheviot porphyrite, 3.
Carboniferous conglomerate, 4.
Shap granite, at least, 30.

Gravel Pit at Pickhill—

Carboniferous conglomerate, 1.

Shap granite also found at Richmond, Swaledale, and Wemmergill, Lunedale,

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Boulders reach their highest limit at about 700 feet—

725 on Wool Moor, above Upsal,
675 on Hood Hill, near Kilburn—

and consist of dolerite, millstone grit, and black limestone.

NORFOLK.

Reported by F. W. HARMER, *F.G.S.*, *and* P. F. KENDALL, *F.G.S.*

Bacton.—On beach—

Rhomb-porphyry, jasper (S. Scotland), opposite Post Office,
2 dolerite, 1 iridescent Laurvikite well striated, about 3 ft. long.

Hellesdon.—Mr. Cunnall's brickyard. Out of chalky boulder clay—

Rhomb-porphyry.

Catton.—Mr. Cunnall's garden, but removed from brickyard—

Many large boulders, including several of basalt, 1 quartz porphyry.
1 Shap granite (now in Norwich Museum).

Happisburgh.—By stables of house called 'The Chimneys'—

Coarse Laurvikite about 3 ft. long.

Walcott.—Outside Post Office—

Many large boulders of dolerite, for the most part little worn.

Pakefield.—Out of chalky boulder clay at brickyard—

Grey and black flints, hard chalk, septaria and fossils from Kimmeridge clay, *Gryphæa incurva*, fossiliferous Spilsby sandstone, porphyrite (Cheviot type), dolerite.

Corton.—In brick-earth—

Flints, dolerite, quartzite pebbles (? from Trias), shell fragments.

Fornsett.—From chalky boulder clay in railway cutting—

Grey and black flints, grey paramoudra with hard chalk adherent, hard chalk, septaria shale and fossils from Kimmeridge clay, dolerite, hornblende schist, Spilsby sandstone, Red chalk with *Bel. minimus*, L. Lias with *Gryphæa incurva*.
Oolitic limestone, Carboniferous sandstone, quartzite pebbles (? Trias).

Scole.—Brickyard ¼ E. of church—

Dolerite 16 in. long.

Tharston.—Chalk pit—

2 large blocks 3 ft. or more in length of coarse dark red sandstone, with millet-seed grains, and containing subangular pebbles of flint. The rock closely resembles a sandstone in the Forest Bed series at Gudram's Gap, Bacton; but Mr. Harmer points out that many of the Upper Tertiary sands form a similar rock when consolidated.
1 Spilsby sandstone with fossils.

Stanfield Hall.—Ballast pit beside railway—

Ganister sandstone with rootlets, millstone grit.

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Wymondham.—Gravel pit in Cannonshot gravels. These gravels are mainly composed of flint, but there is a small percentage of other rocks, including hard sandstones, grits, and dolerites. Two specimens of Rhomb-porphyry.

East Dereham.—Station brickworks. In chalky boulder clay—

Chalk (hard and soft), flints, both black and grey, sandstone, quartzite, ironstone (rather sandy), dolerite, granitoid rock resembling that of Ercal (Wrekin), porphyrite, jasper, greywacke sandstone, 2 ft. by 1 ft. by 1 ft. well striated. (This has been removed to the Norwich Museum.)

In Crown Point brickyard—

Cubic block of Neocomian sandstone with pebbles 1 ft. 4 in. cube, sandstone, dolerite.

At Mr. Horne's cottages—

Block of greywacke sandstone 16 in. cube.
" very ferruginous sandstone (Tertiary), with pebbles of quartz, flint and clay ironstone.

Swaffham.—Railway station. In chalky boulder clay—

Septarian with ammonite (probably Kimmeridge).

Broome Ford, Ditchington—

Kimmeridge shale in boulder clay.

Bedingham.—Pit opposite church. In chalky boulder clay—

Hard and soft chalk, Kimmeridge shale, dolerite.

Hempnall.—By butcher's shop—

Dark green sandstone with fossils, including an ammonite (? Neocomian), 3 ft. by 2 ft. by 1 ft.

Boyland Hall.—Pit at corner of road (½ mile W. of)—

Kimmeridge shale with fossils.
Fossiliferous Spilsby sandstone.

Diss.—In chalky boulder clay—

Neocomian sandstone.

SUFFOLK.

Reported by Messrs. F. W. HARMER, *F.G.S.*, *and* PERCY F. KENDALL, *F.G.S.*

Hoxne.—Brickworks. In chalky boulder clay—

Hard chalk, Kimmeridge shale with *Perisphinctes biplex*, Neocomian sandstone. Oolitic limestone.

Needham Market.—Quinton's brickyard—

Neocomian sandstone, 2 ft. 6 in. long, out of chalky boulder clay.

Sudbury.—Ballingdon Brickyard. In dark-brown chalky Boulder Clay—

Many fragments of Kimmeridge shale and septaria.

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Wattisfield.—By roadside—

Hard sandstone, dolerite, Neocomian sandstone, limestone (? Carboniferous), quartz pebbles (probably from Trias).

Essex.

Reported by Messrs. F. W. Harmer, *F.G.S.*, *and* Percy F. Kendall, *F.G.S.*

Braintree—

Many boulders of ferruginous sandstone (probably Tertiary) and Hertfordshire pudding stone.

Takeley Street.—At Old Mill Inn—

Massive brown sandstone (probably Tertiary), 3 boulders 3 ft. by 2 ft. by 1 ft. 9 in., 1 ft. 6 in. by 1 ft. by 1 ft., 2 ft. by 1 ft. 6 in. by 1 ft. 6 in.
Schist 2 ft. by 1 ft. 6 in. by 8 in. visible.
Other smaller boulders of the sandstone also observed.

Stanstead.—By Old Bell Inn—

Large concretionary masses of dark brown sandstone (Tertiary).

Stanstead.—Through the village—

Many boulders of Tertiary sandstone, some inclosing flint pebbles.

Newport.—The great boulder recorded in the 1884 Report appears to consist of Tertiary sandstone, not of Millstone Grit, as there stated.

Hertfordshire.

Reported by Messrs. F. W. Harmer, *F.G.S.*, *and* Percy F. Kendall, *F.G.S.*

Bishops Stortford.—In brickyard near Isolation Hospital—

Fossiliferous Neocomian sandstone with pebbles at gate of Isolation Hospital.
Brown compact lustrous sandstone passing on one side into Hertfordshire puddingstone, 2 ft. by 1 ft. by 1 ft.

Excavation for new houses, Elm Grove. In chalky boulder clay—

Hard chalk, grey and black flints, green-coated flints (Eocene), *Gryphæa incurva*, *G. dilatata*, *Ostrea deltoidea*, Kimmeridge shale, dolerite, oolitic limestone.

APPENDIX.

(Drawn up by the Secretary.)

Summary of records from England, Wales, the Isle of Man, and Scotland contained in the reports from the year 1873 to 1903 inclusive. A summary of Irish records is embodied in the Report for 1902.

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List of Abbreviations.

A. or And.	Andesite.	Hæm.	Hæmatite.
Agg.	Agglomerate.	Irons.	Ironstone.
Ard.	Ardwick.	Kim.	Kimmeridge.
Aren.	Arenig.	L. or Limes.	Limestone.
Armb.	Armboth.	L. (prefix)	Lower.
Ba.	Basalt.	L. D.	Lake District.
B. (And.)	Borrowdale.	Lamp.	Lamprophyre.
Brec.	Breccia.	Laur.	Laurvikite.
Broc.	Brockram.	M.	Mica.
Butt.	Buttermere.	Markf.	Markfield.
Carr.	Carrock.	M. G.	Millstone Grit.
Charn.	Charnwood.	P.	Porphyrite.
Chev.	Cheviot.	Pal.	Palæozoic.
Cl.	Cleveland.	Perm.	Permian.
C. M.	Coal Measures.	Porph. (suffix)	Porphyry.
Cong.	Conglomerate.	P. S.	Pudding Stone.
Criff.	Criffel.	Rh. P.	Rhomb. Porphyry.
Dalb.	Dalbeattie.	Rhy.	Rhyolite.
Diab.	Diabase.	S. or Sands.	Sandstone.
Dior.	Diorite.	Sch.	Schist.
Dol.	Dolerite.	Sil.	Silurian.
El.	Elæolite.	Sils.	Siliceous.
Esk.	Eskdale Granite.	Syen.	Syenite.
F.	Flint.	Swed.	Swedish.
Fels.	Felstone.	Threl.	Threlkeld.
Gall.	Galloway Granite.	Tr.	Trias.
Gn.	Gneiss.	Yored.	Yoredale.
Greens.	Greenstone.	Yew.	Yewdale Breccia.
H.	Hornblende.		

Anglesea.

1. Frondwl	1881.	Picrite.
„	1885.	Identifies local origin of Picrite.
2. Llanerchymedd	1881.	Horn. Diab. (? Local).
3. Porth Noble	1881.	Picrite.
„	1885.	Identifies local origin of Picrite.
4. Tycroes	1881.	Picrite.
„	1885.	Identifies local origin of Picrite.

Ayrshire.

1. Ballantrae	1901.	Ailsa.
2. Girvan	1901.	Nod. Dol., Ailsa.
3. West Kilbride	1901.	Nod. Dol.

Carnarvonshire.

1. Moel Tryfaen	1881.	Flint.

Cheshire.

1. Adswood	1891.	Gran.
2. Alderley	1893.	L.D.A., C.M. Sands., Quartzite, Gall., Esk., Butt.
„	1895.	L.D.A., Esk.
3. Arden Mills, Woodley	1891.	L.D. And., Esk.
4. Barnston and Pensby	1893.	L.D.A., Yew. Brec., Sil. Grit, Diab., Sands., Gall., Esk.
5. Birkenhead	1879.	Striæ.
„	1897.	Serpentine.
„	1900.	Diab.

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6. Bramall	1891.	Esk., Rhy. Brec., ? Butt., Gran.
7. Bredbury	1891.	Esk.
8. Brimstage	1892.	Gall., L.D.A. Agg., Limes., Sil. Grit.
9. Cheadle	1891.	L.D. And.
10. Chester	1893.	Diab. rare.
11. Clatterbridge	1892.	Fels. L.D.A., Sil. Grit.
12. Dawpool	1877.	Hornb. Felst., Criff., L.D. Grit, Butt. L.D. Volc.
13. Dee Estuary, Burton Rocks, near Kirby.	1893.	L.D.A. Brec. and Ash, Criff., Sil. Grit, Ba., Esk., Butt., Criff., Dalb., Dior., Diab. (? Scott.), Carb. Sands., M.G., Quartzite, Fels., Trias.
14. Delamere Forest	1893.	Diab. rare.
"	1900.	L.D.A., Esk., Ailsa Craig, Criff., Flint.
15. Disley	1899.	Esk.
16. Dukinfield to Lyne Edge	1888.	Fels., Gran., And., And. Ash, Microgran., Esk.
17. Goyt Hall, Stockport	1892.	Gall., L.D.A.
18. Gullden Sutton, near Chester.	1878.	Lias.
19. Hatherlow	1891.	L.D.A., Gall., Gran.
20. Hazel Grove	1891.	L.D. And.
21. Hilbre	1892.	L.D. Agg. and Ash., Diab.
22. Hyde	1891.	L.D. And. Agg. Rhy., Quartz Porph., ? Perm. L., C.M. Sands., Ardwick Limes., Esk., Butt., Gall., ? Sil. Grit.
23. Knutsford	1891.	Gran., ? Gall.
"	1895.	Esk., Butt., Gall., L.D.A.
24. Leasowe Castle	1875.	Greenstone Dior. w. Isorine, Syen., Ash.
25. Little Grange	1892.	Gran., Sil. Grit.
26. Little Storeton	1892.	Yew. Brec., Gall., Sil. Grit, Dior., L.D.A.
27. Lyne Edge to Harrop Edge	1888.	And. Ash., Rhy. Brec., Esk., Vein.
28. Lyme Park	1893.	Gran., L.D.A.
29. Macclesfield	1891.	Gran.
"	1895.	L.D.A.
30. Macclesfield District	1893.	Butt., Esk., L.D.V., Ba., Gall., Gran., Grit.
31. Marple	1891.	Gran., L.D.A. Brec., ? Esk., ? Gall.
"	1892.	L.D.A.
32. Mottram	1891.	L.D.A.
33. Norbury	1891.	Gran., And.
34. Norbury Moor	1891.	L.D. And., Butt.
35. Northen Etchells	1891.	L.D. And. and Rhy. Scott., Flint, Esk., Gall., Ba., Butt., Fels.
36. Offerton	1891.	Esk., Gall, L.D.A. Brec., Rhy., Gran., ? C.M. Sands., Butt.
37. Overton, Taxal	1890.	Butt.
38. Raby to Willaston	1896.	Gall., Sil. Grit, Diab., L.D.A., Butt., Striæ.
39. Rock Ferry	1896.	Striæ.
40. Setter Dog, Macclesfield	1891.	Butt., Dalb.?, Criff., Porph. Gall., Quartzite, L.D. And. Rhy. Agg.
41. Spital	1892.	Fels., Sil. Grit, L.D.A. and Ash., Gall., Butt, Carb. Sands.
42. Stockport	1891.	Esk., L.D. And. Brec.
43. Storeton	1892.	L.D.A., Dior., Sil. Grit, Gall.
44. Styal	1891.	Esk.
45. Taxal	1890.	Eskdale, Butt., L.D. And., Gall., Quartzite, Gall. Gran., Trias.
46. Thornton	1892.	Gran., L.D.A. and Agg., Diab., Sil. Grit.
47. Thornton Hough	1892.	Gran., L.D.A. and Agg., Criff., Dalb., Sil. Grit.
48. Werneth Low	1890.	Esk., Butt., L.D. And. Rhy., Porph. Agg., Sil. Grit, C.M. Sands., Quartzite, Trias.
49. West Kirby	1892.	Ba., Gran., L.D.A. Agg.
50. West Kirby to Park Gate	1879.	Greenstone, Scott. Gran., Dior.

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51.	Wilmslow	1891.	L.D.A., Esk.
52.	Wirral	1876.	Aren.
	,,	1879.	Greenstone.
53.	Woodley	1891.	L.D.A. Rhy. and Brec., Esk., Gall., Butt., ? C.M. Sands., ? Carb. L.
	,,	1892.	L.D., Scott., Ard. Limes.

CUMBERLAND.

1.	Maryport	1881.	Gran., Trias.
2.	Skiddaw	1901.	Striæ.
3.	Whitehaven, Coast N. of	1879.	Criff., Greenstone.

DENBIGHSHIRE.

1.	Cefn Cave	1876.	Aren.
2.	Eryrys	1876.	Aren.
3.	Glyn Ceiriog	1876.	Aren.
4.	Llanrwst Gorphwysfa	1874.	Sils. Congl., Felspc. Stone.
5.	Minera	1881.	Flint, Esk., Aren.
6.	Ruabon	1876.	Aren.
7.	Trevor	1876.	Striæ.
8.	Wrexham	1878.	White sil. Rock (? Jur.).
	,,	1877.	Esk., Trias.

DERBYSHIRE.

1.	Broadhurst Edge	1901.	L.D. And., Rhy., Porph. Fels., Butt, M.G., Grit, Trias.
2.	Bugsworth	1891.	L.D.A. and Rhy. Agg., Criff., M.G., C.M. Sands., Vein Quartz, Butt., Esk., Gall., Flint, Trias, Carb. L. Chert and Sands.
3.	Buxton	1895.	L.D. And. and Ash, Butt., Chert, Ganister, Toadstone.
4.	Chapel-en-le-Frith	1893.	L.D.A., Gran., Vein Quartz.
5.	Doveholes	1893.	L.D.A., ? Gran., Flint.
6.	Hayfield	1893.	L.D.A., Agg., Butt., Esk.
7.	Little Hayfield	1891.	Butt., Esk.
	,,	1892.	Butt.
8.	Millersdale	1893.	L.D.A.

DEVONSHIRE.

1.	Ashburton	1877.	Greenstone.
2.	Barnstaple Bay	1873.	Gran.
3.	Berry Head	1875.	New Reds.
4.	Bickington	1879.	Gran.
5.	Bishop's Teignton	1874.	Travelled Boulders.
6.	Cleve	1880.	Quartzite.
7.	Churston	1875.	New Reds.
8.	Diptford	1880.	Quartzite, Greenstone.
9.	Englebourne	1875.	'Trap.'
10.	Harberton	1877.	Not erratics.
11.	Kingston	1880.	Greenstone.
12.	Maristowe	1880.	Quartz.
13.	Rivalton	1876.	Felsite.
14.	Santon	1873.	
15.	Start Point to Prawle	1880.	Schorlaceous Gran.
16.	Tamerton Foliot	1880.	Quartzite.
17.	Waddeton	1875.	New Red Sand., Dol. Limes.

DURHAM CO.

1.	Barnard Castle	1903.	Whin Sill, Carb. Sands., L.D. And. Asn.
2.	Blackhalls	1903.	Gran. (? Dumfries), Porph. (Chev.), Augen Gneiss, Gneiss, Quartz Porphyry, Gran.

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3.	Beda Hills	1895.	Carb. L. S. and Irons., L.D. And. and Ash, Gran., Quartz Porphyry (? Armb.).
4.	Bishop Auckland	1897.	Shap.
	„	1903.	Carb. L.
5.	Darlington	1887.	Shap.
6.	Durham City	1895.	L.D.A., Gran. (? Scott.).
7.	Etherley	1897.	Shap brought from Tees.
8.	Harperley	1903.	Volc. Brec. (? L.D.).
9.	Harton	1889.	Ba.
10.	Kip Hill	1895.	Carb. L. and S., L.D.A. and Porph.
11.	Lindisfarne	1903.	And. Ash (L.D.).
12.	Low Coniscliffe	1887.	Shap.
13.	Oxenlow	1903.	And. (L.D.).
14.	Piercebridge	1887.	Shap.
	„	1903.	And., Brec. (L.D.).
15.	Sadberge	1887.	Carb. Limes.
16.	Seaham Harbour	1888.	Carb. Limes.

Essex.

1.	Barnston	1888.	Carb. L., M. Sch., Syen.
2.	Bocking Place	1888.	Gneiss.
3.	Braintree	1888.	Gneiss, Carb. L.
	„	1903.	Ter. Sands., H.P.L.
4.	Causeway End	1888.	Sands., Ol. Dol.
5.	Felstead	1888.	Sands., Dol., Porphyrite, Hypersthene Dol.
	„ (General)	1888.	Quartzite, Mica Schist, Quartz Porph., Silicified Wood, M.G. with Shells.
6.	French Green	1888.	Sands, Flint, Porph., Ol., Ba. Dol., Carb. L., Jur. L.
7.	Great Saling	1888.	Dolerite, Ol. Dol.
8.	Great Leighs	1888.	Herts P.S. Sands.
9.	Great Waltham, North End.	1888.	Sands., Herts P.S. Porph.
10.	Great Waltham, Ford End.	1888.	Sands., Carb. L., Flint, Dol.
11.	Little Dunmow	1888.	Ol. Dol., Sands., Flint. Syen., Carb. L., Spher. Felsite, Clunch (? Oxf. Clay), Quartz Tourm. Rock.
12.	Little Saling	1888.	Calc. Sands., Sands. with Bel. (? Kell.), Ol. Dol.
13.	Little Easton	1888.	Sands., Limes. (? Oxf.), Herts P.S.
14.	Little Leighs	1888.	Dol. Fels. Porp. Sands.
15.	Littley Green	1888.	Carb. L.
16	Littley Park	1888.	Sands.
17.	Mill House	1888.	Sands.
18.	Newport	1884 and 1903.	Ter. Sands. (Not M.G. as in 1884 Report).
19.	Pond Park	1888.	Sands. (Neoc.), Septaria, Flint, Herts P.S., Dol.
20.	Potash Farm	1888.	Sands. Quartz-rock.
21.	Snows Lane	1888.	Ol. Dol.
22.	Stanstead	1903.	Ter. Sands.
23.	Stebbing	1888.	Sands., Dol., Ol. Dol., Quartz, Quartzite, Fels., Carb. L., Porph.
24.	Takeley Street	1903.	Ter. Sands., Schist.
25.	Woolpits Farm	1888.	Dol.
26.	Whelpstones Farm	1888.	Sands.

Flintshire.

1.	Bach-y-Graig	1893.	Butt., Gall., Welsh Rocks.
2.	Caergwrle	1876.	Aren.
3.	Greenbâch	1893.	Butt., Gall., Aren. Fels.
4.	Halkin Mountain	1876.	Aren.
5.	Holywell	1876.	Aren.

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6.	Marion Mills	1893.	Carb. L.
7.	Meliden	1893.	L.D.A. and Ash, Gall., Sil. Grit (Scott.), Porph. (? Chev.), Grit (Welsh), Rhy. (Welsh), Sands., Esk., Slates.
8.	Mold	1876.	Aren.
9.	Pandy	1893.	Esk., Butt., Gall., Ailsa, ? Mynydd Mawr, Carb. L.
10.	Tremeirchion	1892.	Ailsa Craig.
	"	1893.	Grits (Welsh), Aren. Fels., Carb. L. and S., M.G., Slate, Quartzite, Trias, Gall., L.D.V.

Haddingtonshire.

1.	Dunbar	1902.	Zirc. Syen., Laurv. (Ballast).

Hertfordshire.

1.	Amwell	1885.	Sand.
2.	Ashwell	1871.	Sands., Sands. Neoc., Carb. L., Ba., Gneiss, Sands. (Ool.), Chalk Marl, Porph. (? Chev.), Gran. c.f. Criff., M.G., S. (? Carb.), ? Sept. Kim. or Oxf., Lr., Lias, L. Ool.
	"	1877.	Sands.
3.	Bayford	1885.	Herts P.S.
4.	Bishop's Stortford	1903.	Chalk (hard), Flint, Green Flints (Eoc.), Lias, Kim. Clay, Dol., Ool., Sands., Necc. Sands., H.P.S.
5.	Brickendon Green	1885.	Herts P.S., Sands.
6.	Bygrave	1883.	Sands.
7.	Essendonbury	1885.	Sands.
8.	Goose Green	1885.	Sands.
9.	Hertford	1885.	Herts P.S.
10.	Hitchen	1883.	Limes. ? Lias, Sands, L. (? Carb. or Sil.), L., Ba., Conc. (? Oxf.), L. (? Ool.), Gran., Carb. L., M.G.
11.	Hoddesdon	1885.	Sands., Herts P.S.
12.	Kelshall	1883.	Ba., Carb. L.
13.	Mangrove Lane	1885.	Sands., Herts P.S.
14.	Royston	1877.	M.G.
15.	Tolmer's Church	1885.	Herts P.S.
16.	Ware	1885.	Sands., Herts P.S.
17.	Westmill (near Buntingford)	1875.	Carb. L.

Isle of Man.

1.	Ballafayle	1891.	Gran.
2.	Ballajora	1891.	Gran.
3.	Claghbane to Ballaskaig	1892.	Dalb., Loch Skerrow Gran., Red Sands., Greenstone, Grit, Vein Quartz, Gran., Slatey Cong., Diab., Clay-Slate, Porph., Quartz, Siln. Grit.
4.	Douglas Head	1893.	Slate (prob. from Dhoon).
5.	Kirkbride	1893.	Vein Quartz, Grit, Queensbury Grit, Criff., Syen., Shap, Gneiss, Porphyry, Pitchstone, Loch Doone Gran., Limes., Sands., Gran.
	"	1896.	Arran Gran., Felsp., Porph.
	"	1897.	Shap.
6.	Maughold	1892.	Biotite Gran., And. Agg., Grit, Gran., Red Sands., Vein Quartz, Loch Doone Gran., Butt., Clay-Slate (local), 'Trap.'
7.	North Barrule (S. side)	1892.	Grit, Micaceous Grit, Vein Quartz, Grit Quartz, Clay-Slate, Dhoon Gran.

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8. Port e Bloggan	1891.	Gran., Ba.
9. Port Lewaigue	1891.	Gran., Grey Gran., Trap.
„ „	1897.	Shap.
10 Port Mooar	1891.	Gran.
11. „ „ Shore	1891.	Gran. (coarse grey), Gran. red, Syen.
12. „ „ to Corna	1891.	Gran., Porphyry.
13. Port e Vullyn to Corna	1891.	Gran., Grey Gran., Pitchstone.
„ „ „	1892.	Pitchstone of Corriegills.
14. Traie na Feeinney	1891.	Gran.
15. Traie Uanaigue	1891.	Porphyry, White Limes., Quartzite.

Lancashire.

1. Arden Mills, near Woodley, Cheshire (for which see other records).	1891.	L.D. Rhy., Esk.
2. Bacup	1888.	Reference.
3. Barton-on-Irwell	1891.	C.M. Sands., Esk., L.D.A.
4. Bolton-le-Sands	1891.	Carb. L.
5. Bootle	1877.	Hornb. Felst., Esk.
6. Bootle Dock	1879.	Greens., Scott. Gran.
7. Castleton, Rochdale	1891.	L.D.A., and Rhy., Butt., Gall., M.G., Esk., Carb. Sands, Quartz Porph., Sil. Grit.
„ „	1892.	L.D.A., Rhy. and Porphyrite, Butt., Gall., Carb. Sands.
8. Cowm Top, Rochdale	1891.	Grit (M.G.), Gall., Esk., Quartzite, L.D. Rhy., Quartz Porpb.
„ „	1892.	L.D.A. and Rhy.
9. Crosby	1879.	Greens., Striæ.
10. Decoy Marsh to Ditton	1893.	L.D.A. and Brec., Felsite, Sil. Grit, Esk, Gall., Butt., Ba., Carb. L. and Sand., Dalb., Dior., C.M. Sand.
11. Dingle Point to Hale Head (River Mersey)	1892.	L.D.A. Brec., Gall., Sil. Grit, Dior., Felsite, Grit, Limes., Sil. Limes., Ba.
„ „ „	1896.	Goat Fell Gran.
12. Facit, Rochdale	1891.	Butt., L.D. Rhy. and A., Quartzite, Quartz, ? Gall.
„ „	1896.	Esk., Quartz Syenite, Butt., L.D.A. and Rhy., Carb. Sands.
13. Fallowfield (Manchester)	1890.	Butt., L.D.A.
14. Greenbooth, Rochdale	1891.	Butt., Quartz Porph., Quartzite, Hæm., L.D.A. and Rhys., ? Gall., Esk.
15. Haughton Green	1891.	L.D.A. and Rhy., Gall., Butt.
16. Hale Head to Decoy Marsh	1892.	Dalb., L.D.A. Brec., Butt., Criff., Dior., Sil. Grit, Gran., Felsite, Trias Sands, Gall., Sands., Esk.
17. Heaton Chapel	1891.	C.M. Sands.
18. Heaton Mersey	1891.	Esk., Butt., L.D.A. Rhy. Brec., Gall., Dalb., Ba., Perid., Quartz Porph., M.G., Carb. L. and Sand., New Red Sand., Sil. Grit.
19. Hey Houses (near Lytham)	1892.	L.D. Porphy. and And., Gran., Butt., Gall.
20. Hest Bank	1891.	Shap, Perm. Congl., Sil. Grit, Carb. L. Chert., Sands., M.G., L.D. Brec., Rhy. and And., Mica Trap.
21. Heywood	1891.	Carb. L., L.D.A., Esk., Butt., ? Gall., Grit, Quartzose Rock, Gran., Vein Quartz, ? Syenite.
22. Hopwood, near Rochdale	1892.	Limes., Gall., Gran., Butt., L.D.A.
23. Irlam	1891.	C.M. Sands.
24. Kensington, near Liverpool	1875.	L.D.V.

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25.	Langden End, near Rochdale	1892.	Gall., Butt., Esk., L.D.A. and Porph., Quartz Felsite.
26.	Levenshulme	1891.	C.M. Sands., Ard. Limes.
	,,	1893.	Ba., Gall., Sil. Grit, C.M. Sands.
27.	Liverpool	1875.	L.D.V.
28.	Manchester	1880.	Grit.
	,,	1891.	C.M. Sands.
	,,	1893.	Gall.
29.	Millbottom to Micklehurst	1888.	Esk., And. Ash, Fels., Syenite, Vein, Butt.
30.	Moorside, near Rochdale	1891.	Sil. Grit., Butt.
31.	Newchurch in Rossendale	1889.	L.D.V.
32.	Old Trafford	1890.	C.M. Sands.
33.	Piethorne, Rochdale	1878.	Lias.
34.	Rawtenstall	1890.	L.D.A., Butt., Gran., Esk., Gall., Criff. Gran., Vein Quartz, Carb. L. and Chert, Red Sand.
35.	Rochdale	1891.	Gall., Carb. Sands., Butt., L.D. Agg., Quartz Porph.
	,,	1892.	Carb. Sands, Esk., L.D.V., Quartzite, L.D.A. Butt., Gran.
	,,	1893.	Quartz Porph., Granophyre, L.D.A. Brec. Rhy., Butt., Esk., ? Gall., Sil. Grit., Quartzite, Carb. L. Grit and Sand., Hæm., Butt.
36.	St. Helen's	1891.	Butt., Sil. Grit, Gall., Gran., ? Esk., L.D.A.
37.	Scambrick	1874.	Gran.
38.	Shaw Moor	1888.	L.D.V., Criff.
39.	Snape	1874.	Gran.
40.	Sparth Bottoms, Rochdale	1891.	Gall., L.D.A. and Rhy., M.G., Carb. L. and Sands., Esk., Quartzite, Hæm.
	,, ,, ,,	1892.	L.D. Porphyrite, Gall., Carb. Sand.
41.	Swaindrod, near Rochdale	1892.	Gneiss, Gran., ? Gall.
42.	Spotland, Rochdale	1890.	L.D.A., Criff., Carb. Sand.
43.	Stonyhurst	1891.	Perm., Marl. and Sands., L.D.A. and Rhy., Butt.
44.	Wardle, near Rochdale	1890.	Carb. Sands.
45.	Whitworth, near Rochdale	1896.	Carb. Limes.

Leicestershire.

1.	Aylestone	1878.	Syen. (Charn.) Flint.
	,,	1880.	Syen.
	,,	1881.	Syen.
	,,	1882.	M.G. Sands., Markfield Syen.
2.	Beeby	1877.	Coal.
3.	Bushby	1880.	Syen. (Mt. Sorr.)
4.	Carlton	1880.	Ash, Syen.
5.	Countesthorp	1880.	Trias, Ool. L., 'Greenstone,' M.G.
6.	Desford	1874.	Syen., Gran., Greenstone, Ba. Chert, Carb. L., Lias, Sands.
7.	Evington	1877.	Gran., M.G., Limes., Chert, C.M. Sands., Trias, Syen., Greenstone.
	,,	1878.	Syen., Trias, M.G., Carb. Limes., Gran. (Mt. Sorr.)
8.	Hallaton	1883.	Flints, M.G., Carb. L., C.M. Sands., ? Marlstone.
9.	Hoby	1874.	Syen., Gran., Greenstone, Ba., Chert, Carb. L., Lias, Sands.
	,,	1875.	M.G., Ba.
10.	Hugglescote	1873.	(Charn.) Rocks., M.G., Greenstone.
11.	Humberstone	1878.	Syen. (Mt. Sorr.)
12.	Kirby Muloe	1883.	Markf., Syen.
13.	Knighton	1881.	Syen. (Mt. Sorr.)
	,,	1882.	L. Lias, Gran., Syen., Greenstone.

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14. Leicester	1874.	Dol. or ? Dior. (? non-British).
,,	1878.	Syen.
,,	1880.	Syen., Chert.
,,	1881.	M.G., Gran., Gran., Syen., Slate, Grit, Sands., Carb. L., Ool., Lias L., Marl-St., Chalk, Coal, Shale, C.M.
,,	1882.	Syen. of Enderby or Croft.
,,	1883.	Gran. (Mt. Sorr.)
,,	1886.	M.G., Carb. L., L. Ool., Syen. (Charn.), Coal.
,,	1888.	Gran. (Mt. Sorr.), M.G., Ool., Lias L.
15. Leicester Abbey	1874.	? M.G. or Trias.
16. Leicester Forest	1883.	Markf., Syen.
17. Loseby	1877.	Gran., Quartz, Coal.
,,	1878.	M.G., Flint, Chalk, Lias, Sands.
18. Loughborough to Ashby	1883.	M.G.
19. Market Bosworth	1880.	Ash, Agg. (Charn.), Syen.
20. Melton	1874.	Syen., Gran., Greenstone, Ba., Chert, Carb. L., Lias, Sands.
21. Newfound Pool	1888.	Groby or Markf., Bone of Whale.
22. Newton Unthank	1883.	Markf., Syen.
23. Normanton	1875.	(Charn.) Forest Rocks.
24. Oadby	1880.	Gran. (Mt. Sorr.)
25. Ratliffe	1874.	Syen. Gran., Greenstone, Ba., Chert, Carb. L., Lias, Sands.
26. Ridgeway	1880.	Gran. (Mt. Sorr.)
27. Saffron Lane	1882.	Gran. (Mt. Sorr.), Ba., M.G., Carb. L. and Chert, L. Lias.
28. St. Margaret's, Evington	1878.	Syen., Trias, M.G., Ool.
,, ,,	1881.	Gran. (Mt. Sorr.), M.G., Sl. (Swithland).
29. Shakerstone	1875.	Porph. Greenstone of Whitwick, Gran., Syen., Ba.
30. Stoughton	1881.	Syen. (Mt. Sorr.)
31. Sayston	1880.	Ash, Agglom. (Charn.).
32. Thurnby	1877.	Gran., Syen., Greenstone.
,,	1880.	Syen. (Mt. Sorr.), Breo., Trias or Perm.
,,	1882.	Carb. L., M.G., Perm.

Lincolnshire.

1. Aylerby	1898.	Whin Sill, Sands., Gran.
2. Barnoldsby	1898.	Whin Sill.
3. Barton on Humber	1896.	Shap, Ba., ? Gran.
4. Beechby	1898.	Quartzite.
5. Benniworth	1896.	Aug. Syen. (Laurv.), Sands.
6. Bradley	1898.	Gran., Quartzite, Sands., Ba.
7. Bradley Wood	1898.	Whin Sill.
8. Brigsley	1898.	Sands., Ba., Whin Sill.
9. Brocklesby	1896.	Sands. (Primary), Ba., Quartz.
10. Cadeney	1901.	Augen-Gneiss, ? Limes., Neoc., Red Chalk, Ba., Limes. (? Lias), Sands., Shale.
11. Cleethorpes	1901.	Rh. P., El. Syen., Chev. Porph., Gray Eycott Hill Dol., Flints (Grey, Black, Pink, and Green).
12. E. Ravendale	1898.	Sands., Whin Sill.
*13. Gainsborough	1900.	Shap, Greenstone.
14. Great Coates	1898.	Ba., Rh. P., Gran., Ool. Limes., Schist, Limes., Sands.
15. Grimsby	1895.	Gran., Syen., Dol.
16. Brigg Howsham	1896.	Spilsby Sands.
17. Humberstone	1898.	Ba., Sands., Whin Sill, Quartzite.

* Doubtful records, almost certainly brought by barges.

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18. Irby	1896.	Shap, Ba., Sands. (Secondary), Gran.
19. Kirmington	1896.	Rh. P.
20. „	1895.	Dol., Sands. (? Jur.), Gran.
„	1896.	Ba., Gran., Rh. P., Laurv., Lamprop., Dior., Gneiss, Quartz Porph., Carb. L. and G., Lias, Porph., Halleflinta, M. Schist, Flint (Black and Green), Ba., Congl., M.G., Irons. (? Lias), Septarian (? Kim.).
„	1897.	Laurv., Rh. P., Carb. L.
„	1898.	Basic Rock (Hitterdal).
21. Ludborough	1896.	Ba.
22. S. Elkington	1896.	Gran.
23. S. Ferriby	1896.	Rh. P., Quartz P., Ba., Carb. L. and S., Black Fl., Shap, Gneiss, Schist, Gran., Sands, Porph., Limes. (? Ool.), M.G.
24. Stewton	1896.	Ba.
25. Ulceby	1896.	Ba.
26. Waltham	1896.	Ba.

Merionethshire.

1. Carnedd-y-ci	1900.	Quartzite and Greenstone from Cader Berwyn.
2. Glyn-Ceiriog	1900.	Welsh Felsites and Denbigh Grits.
3. Llandrillo	1900.	Ash and Greenstone.
4. Llan-y-cil (Bala)	1876.	Striæ, Aren.

Montgomeryshire.

1. Kerry Hill	1883.	Sil. Grit.

Norfolk.

1. Bacton	1903.	Rh. P., Laurv., Dol., Jasper.
2. Bedingham	1903.	Kim. Clay, Dol., Chalk (Hard and Soft).
3. Boyland Hall	1903.	Neoc. Sands., Kim. Clay.
4. Broom Ford, Ditchington	1903.	Kim. Clay.
5. Catton	1903.	Shap, Quartz Porph., Ba.
6. Corton	1903.	Flints, Dol.
7. Diss	1903.	Neoc. Sands.
8. E. Dereham	1903.	Sands., Quartzite, Irons., Dol., Granitoid Rock (like Rock from Ercal (Wrekin), Porph., Jasper, Greywacke, Neoc. Sands., Ter. Congl., Flint, Chalk (Hard and Soft).
9. Forncett	1903.	Chalk, Flints, Kim. Clay, Dol., Hornb. Sch., Quartzite (? Trias), Neoc. Sands., Carb. Sands., L. Lias., Ool., Red Chalk.
10. Happisburgh	1903.	Laurv.
11. Hellesdon	1903.	Rh. P.
12. Hempnall	1903.	Neoc. Sands.
13. Pakefield	1903.	Flints, Hard Chalk, Kim. Clay, L. Lias, Neoc. Sands., Porph. (? Chev.), Dol.
14. Scole	1903.	Dol.
15. Stanfield Hall	1903.	Ganister, M.G.
16. Swaffham	1903.	Sept. with Amm. (? Kim.)
17. Tharston	1903.	Ter. Sands., Neoc. Sands.
18. Walcott	1903.	Dol.
19. Wymondham	1903.	Sands., Grit, Rh. P., Dol.

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NORTHUMBERLAND.

1.	Akeld	1900.	Porph. (? Chev.), Greywacke.
2.	Little Mill	1895.	Dol., Sands., Carb. L., Jasper, Porph. (? Chev.), Striæ.
3.	Rochbury (? Rothbury)	1874.	Carb. Sands.
4.	Roddam Dene	1900.	Porph. (? Chev.), Greywacke.

NOTTINGHAMSHIRE.

1.	Harworth	1897.	Chalk, Flint, Mag. L.
2.	Plumtree	1875.	Lias L.
3.	Stanton	1875.	Lias L.
4.	Sth. Notts	1875.	Quartzite (? Trias), M.G., Carb. L.

OXFORDSHIRE.

1.	Wolvercote	1876.	Sands. (? Ter.)

PEMBROKESHIRE.

1.	St. Davids	1885.	Picrite.

RADNORSHIRE.

1.	Beguildy	1883.	Sil. Grit.
2.	Rhayader	1885.	Ditto.

SHROPSHIRE.

1.	All Stretton	1900.	Trias.
2.	Bridgenorth	1876.	Esk.
3.	Cefn	1876.	Aren.
	,,	1878.	Ditto.
4.	Chirk	1876.	Ditto.
	,,	1878.	Ditto.
5.	Church Stretton	1900.	Criff., Esk., Butt., Perm. Sands.
6.	Claverly	1883.	Gran., Fels.
7.	Clunbury Hills	1883.	Sil. Grit.
8.	Clun	1882.	Ditto.
	,,	1883.	Ditto.
	,,	1883.	Quartzites (Stiperstones).
9.	Comley	1900.	Eskdale.
10.	Crickheath	1892.	Striæ.
11.	Ellesmere	1878.	White sils. Rock (? Jur.).
12.	Halfpenny Green	1883.	Vein Quartz.
13.	Ketley, Wellington	1873.	? L.D. Gran., ? Scott. Gran., Charnw., Greenstone, O.R.S., Sil. Limes., Shells.
14.	Leebotwood	1883.	Gran. (Scott. or L.D.)
15.	Lilleshall	1877.	Felst.
	,,	1886.	Shells.
16.	Llanfair Waterdine	1883.	Sil. Grit.
17.	Llanymynech Hill	1892.	Argillite, Limes., Caradoc Sands., Trap, Striæ.
18.	Shifnal to Tong	1887.	Esk., Syen. (? Scott), Criff., Butt., And., And. (? Welsh), Gran. (? Scott.), Quartz Fels., L.D. Rhy.-Brec.
19.	Waystone	1883.	Felstone.
20.	Wellington	1886.	Shells.
21.	Welsh Frankton	1878.	Aren., Sil. Grit, Carb. Sands. and Quartzite.
22.	Wroxeter	1877.	Felst.

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STAFFORDSHIRE.

1. Burton-on-Trent	1878.	M.G., Syen., Lias.
2. Codsal	1887.	Gran., Esk., L.D.V., Felstone (? Scott.), Gran. (? Scott.), Criff., Felstone (? Welsh), Butt., Porph. Scott., Volc. (? Chev.), Ash.
3. Colton	1883.	Criffel, Aren.
4. Gunston	1887.	Gran. (? Scott.), ? Butt.
5. Hanley	1893.	L.D. And. and Agg., Butt., Gall., M.G., Esk., Trias.
6. Harborne	1873.	Gran.
„	1876.	Quartzite, Vein Quartz.
7. Gospel Ash	1883.	Butt., Felsite, Mica Syen.
8. Highgate Common	1883.	Gran.
9. Little Madeley	1891.	Gran., Chalk, Flint, Shells.
10. Madeley	1891.	Trap, Gran.
11. Manor Green, Walsall	1879.	Fels.
12. Moseley Hole	1879.	Gran.
13. Needwood Forest	1878.	Carb. L. and Chert, Yored. Sands., M.G. (? Gran.), Porphyry, Syen., Greenstone, Trachyte, Toadstone, Lias, Ool.
14. Newcastle, Stoke-on-Trent	1877.	Felst., Gran.
15. Red Hill Farm, nr. Stafford	1873.	Gran.
16. Rugeley	1883.	Aren. Fels.
17. Tettenhall	1873.	Gran.
18. Wolverhampton	1876.	Criff., Esk.
„	1879.	Fels., Gran., Slate, Quartzite (Trias).
„	1886.	Flint, L.D. Scott.
19. Wightwick	1877.	Felst.

WARWICKSHIRE.

1. Baddesley	1874.	? Scand. Quartzites (Camb.), Carb. L. and S., Chert, Lias, Gt. Ool., Cornb., Felst. (Cumb. or N. Wales) Wrekin Volc., Amygd. Gran. (? Malv.), Palc. Limes., Greens., Trap, Volc. Grit, Gran., Syen., Grit, Quartz, Jasper, Agate, Slate, Sands., Felst., Dol., Chalk, For. Marble, Gt. Ool., Lias, Mag. L., M.G., Perm., Sil. Fossil.
2. Birmingham	1882.	Felsites and Ash (Aren.), Shale, Quartz Congl., Flagstone, Quartzite, M.G., Sil. Sands.
„	1886.	
3. California	1874.	Striæ.
„	1886.	Aren.
4. Coventry	1895.	Mt. Sor. Syen., Syen. c.f. Sapcote.
5. Eddsone	1874.	? Scand., Quartzites (Camb.), Carb. L. and S., Chert, Lias, Gt. Ool., Cornb., Felst. (Cumb or N. Wales) Wrekin Volc., Amygd Gran. (? Malv.) Palc. Limes., Greens. Trap, Volc. Grit, Gran., Syen., Grit Quartz, Jasper, Agate, Slate, Sands., Felst. Dol., Chalk, For. Marble, Gt. Ool., Lias Mag. L., M.G., Perm., Sil. Fossil.
6. Exhall	1890.	Vein Quartz.
7. Hatton-Wilmcote	1874.	Flints and Chalk.
8. Hatton	1874.	? Scand., Quartzites (Camb.), Carb. L. and S., Chert, Lias, Gt. Ool., Cornb., Felst. (Cumb. or N. Wales), Wrekin Volc., Amygd. Gran. (? Malv.), Pal. Limes., Greens., Trap, Volc. Grit, Gran., Syen., Grit, Quartz, Jasper, Agate, Slate, Sands., Felst., Dol., Chalk, For. Marble, Gt. Ool., Lias, Mag. L., M.G., Perm., Sil. Fossil.
9. Hazeler	1874.	Ditto.

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10. King's Norton	1884.	Fels. Ash (Aren.).
11. Knowle	1874.	? Scand., Quartzites (Camb.), Carb. L. and S., Chert, Lias, Gt. Ool., Cornb., Felst. (Cumb. or N. Wales), Wrekin Volc., Amygd. Gran. (? Malv.), Pal. Limes., Greens., Trap, Volc. Grit, Gran., Syen., Grit, Quartz, Jasper, Agate, Slate, Sands., Felst., Dol., Chalk, For. Marble, Gt. Ool., Lias, Mag. L., M.G., Perm., Sil. Fossil.
12. Lapworth	1874.	Ditto.
13. Packwood	1874.	Ditto.
14. Preston	1874.	Ditto.
15. Rowington	1874.	Ditto.
„	1874.	Ool., Chalk, Flint.
16. Sherbourn	1890.	M.G., Gran.
17. Stirchley	1884.	Fels., Slate, C.M. Shale, Car. Grit, Trias.
18. Temple Balsall	1874.	? Scand., Quartzites (Camb.), Carb. L. and S., Chert, Lias, Gt. Ool., Cornb., Felst. (Cumb. or N. Wales), Wrekin Volc., Amygd. Gran. (? Malv.), Pal. Limes., Greens., Trap, Volc. Grit, Gran., Syen., Grit, Quartz, Jasper, Agate, Slate, Sands., Felst., Dol., Chalk, For. Marble, Gt. Ool., Lias, Mag. L., M.G., Perm., Sil. Fossil.
19. Watton Wawen	1874.	Ditto.
20. Wroxall	1874.	Ditto.

Westmoreland.

1. Brackenber Moor, Hilton	1903.	Shap.
2. Burney, near Milburn.	1903.	Whin Sill, Carb. Sands.
3. Castle Hill, Kendal	1878.	Shap.
4. Cunswick Scar	1878.	No Limes. Sil., L.D.V.
5. Farleton Fell	1878.	Carb. L., Sil.
6. Hazelrig, near Gamblesby	1903.	Basement Carb., Gran. (Gall.), Lampro. (c.f. Knock Pike), Shap, Dalb. Gran., Whin Sill.
7. Helm	1878.	Shap.
8. Helm End	1878.	Shap.
9. Hincaster	1878.	Shap.
10. Kendal	1878.	Shap, L.D.V.
11. Kent River	1878.	No Shap, W.
12. Larkrigg	1878.	Shap.
13. Milburn	1903.	Whin Sill, Carb. Limes. and Sands.
14. Milnthorpe	1878.	Shap.
15. Natland	1878.	Shap.
16. Oxenholme	1878.	Shap.
17. Scout Scar	1878.	No Limes., but Sil., L.D.V.
18. Sedgwick	1878.	Shap.
19. Sellet Hall	1878.	Shap.
20. Spital Wood	1878.	Shap.
21. Stainton	1878.	Shap, L.D.V.
22. Storth End	1878.	Shap.
23. Wath Sutton	1878.	Shap.
24. Whitbarrow	1878.	Sil., L.D.V.
25. Windy Hill, near Kendal	1878.	Shap.

Worcestershire.

1. Bromsgrove	1875.	Felstone, Ash.
„	1886.	Welsh.
2. Burcott	1875.	Ash, Prem. Brec.
3. California	1876.	Gran.
4. Canister	1875.	Ash.

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5. Catshill	1875.	Porph.
„	1878.	Aren.
6. Clent	1883.	Felstone.
7. Frankley Hill	1879.	Ba., Diab. (Aren.), Felsites.
8. Fringe Green	1875.	
9. Hagley	1875.	Aren.
10. Hales Owen	1876.	Fels. (Aren.)
11. King's Norton	1875.	Felstone.
12. Northfield and King's Norton	1875.	Felstone, Porph.
13. Perry Hall	1875.	Ba., Ash.
14. Ran Dan Woods	1875.	Ash.
15. St. Claines, near Worcester.	1887.	Criff.
16. Stoke Elm	1875.	Felstone, Ash, Sil. L.
17. Whetley	1875.	Porph.
18. Woodcote Farm	1875.	Ash.
19. Woodrow	1875.	Porph.
20. Worcester	1892.	Vein Quartz, Agate, Butt., Welsh V., Flint, Esk., Gall. Wrekin Rh., Sil. L.

YORKSHIRE.

1. Airy Hill, Hunmanby	1888.	Jur. Sands, Gran., Shap, Ba.
2. Airton	1887.	Carb. Cong.
3. Aldbrough, Holderness	1902.	Haggis.
„	1903.	Tooth of Mammoth.
4. Aldfield	1902.	Ba.
5. Ainthorpe, near Danby	1899.	Porph., L.D.V.
6. Arkendale	1889.	Carb. Limes.
7. Atwick	1896.	Shap.
„	1898.	Gneiss, Shap.
„	1900.	Shap, Laurv., Rh. P.
8. Ayton, near Scarborough	1901.	Rh. P.
9. Balby, near Doncaster	1890.	Limes., Gran.
„	1896.	Mag. L., C.M. Sands. &c., M.G., Carb. L. Chert, Gypsum, Tr. Quartzite, Tr. or Perm. Sands., L.D.V., Threl., Gran., Shap.
„	1897.	Ba., Granoph., Gran., Gneiss, Volc. Aggl., Quartz Porph.
„	1898.	Esk.
10. Baldersby	1887.	M.G.
„	1895.	Shap.
11. Bainton-on-Wolds	1899.	Ba., Brock, Gran., Grit.
12. Bannacks	1895.	Carb. Sands.
13. Barnsley	1895.	Shap, Gran., Rhy., ? Armb., Butt., And., Ba., Carb. L., Mag. L., Flints, I. Lias.
14. Bartindale, North Burton	1901.	Ba.
15. Barton (N.R.)	1891.	Shap.
16. Barugh Hill, R.H. Bay	1900.	Porph., Ool. L.
17. Bempton	1887.	Ba.
„	1888.	Sands., Ba.
18. Bentham	1889.	'Fourstones.' Not erratic.
19. Bilborough	1896.	Carb. L. Sands. and Chert, Trias, Mag. L., Ba., Shap, Clay Ironstone.
20. Blackstone Edge	1896.	L.D.V.
21. Bold Venture, near Hutton	1899.	Porph., Volc. Ash.
22. Bowes	1903.	Shap.
23. Bowland	1896.	? L.D.V.
24. Bradford	1875.	B. And.
„	1896.	Carb. L.
25. Brandsburton	1899.	Rh. P.
26. Brantingham Thorp	1899.	Rh. P.
27. Branton	1896.	Gran.

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28. Brearly	1896.	Gran., Butt.
29. Bridlington . . .	1899.	Sands., Shap, Ba., Carb. L.
,,	1903.	Trachyte (S. Scotland).
30. Brigham Hill, near N. Frodingham.	1899.	Rh. P.
31. Brompton, near Northallerton.	1901.	Rhy., Ba., ? Gabb., Carb. L.S.
,, ,,	1903.	And. (Borr.)
32. Brough-on-Humber . .	1898.	Rh. P.
,,	1903.	Laurv.
33. Buckton (Flamborough Head).	1888.	Ba., Sands.
34. Burmiston. . . .	1889.	Shap.
,,	1898.	Shap.
35. Burstwick	1900.	Shap, Rh. P.
,,	1902.	El. Syen.
,,	1903.	Trachyte (? Eildon Hills), Dol. (? Black Hills), Quartz Porph.
36. Carlton Bank . . .	1899.	Carb. Grit, Porph., Volc. Ash.
37. Carnaby	1902.	Ba.
38. Castleshaw . . .	1889.	Syen. (? Butt.), Sil. Grit, Esk. Horn. Trap, ? L.D.A.
39. Cayton	1888.	Ba., Gran., Carb. L. Sands.
40. Cayton Bay . . .	1899.	Shap.
41. Chalk Villa . . .	1895.	Sch., Gran., Ba.
42. Cherry Burton . . .	1901.	Chev. Porph., Ba., Greywacke, Lias.
43. Church Carlton, nr. Barnsley.	1903.	Micro. Gran.
44. Claro	1889.	Carb. L.
45. Claro Hill	1897.	Shap.
46. Cloughton	1898.	Chalk.
47. Coast Cloughton to Hornsea.	1879.	Shap.
48. Commondale . . .	1899.	Porph., Sparag. ? H. Sch., Shap.
49. Coney Garth, near Brandsburton.	1899.	Rh. P.
50. Coniston, Holderness .	1896.	Gran.
51. Cotherstone, Barnard Castle.	1897.	Shap.
52. Cottingham . . .	1895.	Ba.
53. Coxwold	1902.	Carb. L., S. and Ch., L.D.A.
54. Cropton (V. of P.) . .	1888.	Sands.
55. Crosspool (730 O.D.), near Sheffield.	1883.	Felstone, Felsite, Quartz, Fels., Tuff, Mag. L., Slate, Sands., Rhy., ? Sil. Grit, Qzite., Carb. Chert, ? Trias, M.G. The Volcanics prob. L.D., and others from S. of Scotland.
56. Cundall, near Boroughbridge.	1888.	Shap.
57. Cutsworth and Sprotborough.	1897.	Shap, Orth., Porph., Dior., Ba., Carb. Grit, Carb. L., Gran.
58. Cusworth, near Doncaster .	1900.	Ba.
59. Danby	1899.	Porph. Gran., Rh. P., Porph. Gran., Flint, Ba.
60. Dearne Valley . . .	1896.	Gran, Ba., Carb. L., Rhy. and And.
61. Deepdale	1887.	Shap.
62. Dewsbury	1892.	Butt. Gran.
63. Dimlington . . .	1898.	Laurv., Rh. P.
,, . . .	1901.	Eycott Dol., Carrock.
,, . . .	1902.	Zir. Syen., Swed., C.M., Chalk.
64. Doncaster	1897.	Ba.
65. Driffield	1889.	Ba., Carb. L. and S., Lias, Gran., Ba.
,, ...	1902.	Rh. P.
66. Easington (Holderness) .	1890.	Boulders.

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66. Easington (Holderness)	1898.	Shap, Rh. P., Gran., Laurv., Gneiss, Ba., Carb. L. Sands. and Basement, Brock, Mag. L., Lias, Crioceras, Black and Pink Flint, *Bel. lanceolata.*
„	1902.	Shap.
67. Easington Beck (N.R.)	1896	Shap.
68. East Ayton	1899.	Sch.
69. Eastington Moor	1899.	Gn., Rh. P.
70. East Hutton	1889.	Ba.
71. Egton	1902.	H.
72. Elland	1893.	Esk., Butt., L.D.V., Carb. L.
73. Elloughton (Brough).	1899.	Laurv.
74. Elmire	1887.	Shap.
75. Elton, near Beverley	1901.	Chev. Porph., Greywacke, Lias.
76. Escrick	1902.	Carb. L
77. Extwistle Moor	1903.	Sil. Grit.
78. Falsgrave	1891.	Ba., Gran., Lias, Syen., Quartzite, M.G., Carb. L., Ool., Chalk F.
79. Far Hollingworth	1896.	Gran., Butt.
80. Ferriby Common	1901.	Rh. P., Ba., Carb. L.
81. Filey	1879.	Shap.
„	1880.	Shap.
„	1888.	Ba., Mica T., Limes., L. Lias, Quartz F., Freestone, Shap, Sands., Ba.
„	1890.	Ba., Sands., Carb. L. Grit, Ool. Sands.
„	1899.	El. Syen., Lias, Rh. P.
82. Flamborough	1879.	Shap.
„	1887.	Gran., Ba., Sands., M. Sch., Limes.
„	1888.	Ba., Sands.
„	1899.	Rh. P.
83. Flaxby, near Boroughbridge	1903.	Whin Sill.
84. Flaxton	1889.	Carb. L.
85. Flinton	1896.	Sands.
86. Flixton (Filey)	1889.	Carb. L. and S. Sands., Ba.
87. Folkton	1891.	Ba., Carb. L., Dior., Sands.
88. Fordon-on-Wolds	1900.	Gneiss, Ba., Carb. Sands.
89. Foston-le-Clay	1889.	Limes., Gran., Shap, Sands.
90. Fulford	1896.	Carb. L. and Chert, Sands., L.D.V.
91. Ganton	1891.	Shap, Ba., Ool. Sands.
92. Gardham (near Beverley)	1901.	Chev. Porph., Ba., Carb. L.
93. Garton (Holderness)	1898.	Carb., Basement, Carb. L. and Sands., M.G., Lias, Gneiss, Gran., Ba., Rh. P., Quartzite, Porphyrite.
94. Garton-on-Wolds	1899.	Rh. P.
95. Giggleswick	1902.	M.G., Carb. L. Sh. Grit, Sil. Grit.
96. Goathland	1899.	Sch., Gneiss, Cleveland Dyke, Flint, Trias, Ool. Sands., Chev. Porph., ? Sparag., Fels., Ba.
97. Gordale	1897.	Carb. Congl.
98. Great Ayton	1899.	Porph., M.G., Carb. L. and Ch. L. and M.G., Lias, Trias, Jur. Grit, Mag. L., Flint.
99. Green Dyke (Peak)	1899.	Quartz P., Porph., Gran., Ba., H.
100. Grimdale-on-Wolds	1901.	Ba.
101. Gristhorpe	1888.	Sands., Ba.
„	1899.	Rh. P.
„	1902.	Gabbro (Norse), P. and Jasp., Quartz Porph.
102. Grosmont	1888.	Shap.
„	1896.	Shap.
103. Guisborough	1888.	Gran.
„	1896.	Shap.
104. Haddockstones	1899.	Not Erratics.
105. Harfa Bank	1899.	Carb., Ch.
106. Harrogate	1896.	M.G.
107. Hazelgrove to Marske	1896.	Carb. L., Yore. L., Ba., Whin Sill.

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108.	Hawks Clough, Calder Valley.	1896.	Vein Calcite, Sil., Quartzite.
109.	Hayburn Wyke . . .	1902.	Haggis Rock.
110.	High Catton . . .	1896.	Carb. L., Sands., and Chert, Flint, Carrock, Mag. L., Trias, Brock, L.D.V., Shap.
111.	High Lee	1896.	Vein Quartz (Pebble).
112.	Holderness Coast . .	1896.	Analysis of 310 Boulders.
	" . . .	1897.	Swed., *Bel. lanceolata*.
113.	Holtby	1896.	Carb. Sands., L. and Chert, Carb. Basement, Ba., Keup. Marl, Gyps., Trias Sands., L. Lias, L.D V., Ba., Mag. L., Shap, Scott. Gran. (? L. Doone.)
114.	Horbury	1893.	Esk., Butt., L.D.V., Quartzite, Vein Quartz, Chert.
	"	1901.	Shap, Brockram, Rh. P., Flint.
115.	Hornsea	1879.	Shap.
	"	1896.	Carb. L., Ba.
	"	1898.	Shap.
	"	1901.	L.D.V., Armb.
	"	1902.	Rh. P., Shap, L.D.V., Queensbury Grit.
	"	1903.	M.G., Keuper Marl, Gran., Augen-Gneiss, Gran. (Dalb.)
116.	Hunmanby . . .	1888.	Shap. Sands., Gran.
	" . . .	1889.	Sands., Ba.
117.	Hutton, near Guisborough	1899.	Porph.
118.	Hutton Bushel . . .	1900.	Chev. Porph., Mag. L., Kim. Gneiss, Gran.
	" . . .	1901.	Rh. P.
119.	Hutton Moor, near Ripon .	1887.	Gran., M.G.
120.	Iburndale	1899.	Shap, Gran., Porph.
121.	Ingleby Greenhow . .	1887.	And. and Porph , Chev. and S., Scott., Ba., Cl. Dyke, ? H. Criff., ? Shap, Kelso Trap.
	" . .	1888.	Ba., ? Criff., Greywacke, Vein Quartz, Threl. Quartz Porph., L.D.V., M.G., Carb. L.S. and Grit, Jur. S.
122.	Ingleton	1892.	Lamprophyre.
123.	Keighley	1874.	Hitchingstone, M.G.
	"	1879.	Not erratic.
124.	Kelsey Hill . . .	1903.	Carb. L.
125.	Kettleness	1901.	Chev. Porph., El. Syen., Gneiss.
126.	Kilburn	1902.	Shap, And., Ash.
	"	1903.	Dol., M.G., Limes. (Carb.)
127.	Kilnsea	1890.	Shap.
128.	Kirkby Underdale . .	1888.	Ool. L.
129.	Kirklington, near Ripon .	1895.	Ba.
	" "	1901.	Carb. Sands.
130.	Kirkmoorgate, R.H.B. .	1900.	Rh. P.
131.	Kirkthorpe . . .	1893.	Esk., Butt , L.D.V.
132.	Laithkirk	1890.	Shap.
	"	1893.	Shap.
133.	Langcliffe (Settle) . .	1902.	Striæ.
134.	Lealholm	1899.	Flint, Porph., And , Gran., ? Sparag., Quartzite, Ba., Ool. L., Carb. Chert, Mag. L., M.G., Quartzite, Porph.
135.	Lebberston . . .	1888.	Ba., Sands.
136.	Leconfield	1901.	Chev. Porph., Greywacke.
137.	Leeds	1887.	M.G.
138.	Lindholme Hall, Hatfield Chase.	1888.	Mag. L., Carb. Sands., M.G., Chert, Porph., Ba., Quartzite, Vein Quartz, Flint, Congl., Halleflinta.
139.	Lindrick (Ripon) . .	1893.	Shap.
140.	Linton Wharfedale . .	1903.	Sil. Sl.
141.	Little Weighton . .	1902.	Chev. Porph.
	" . .	1903.	Ba., Quartzite, Sands.
142.	Lockington . . .	1890.	? M.G.

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143. Lockwood	1899.	Porph.
144. Long Lee	1896.	Butt., L.D.V., Esk.
145. Lowthorpe	1890.	Ba., Carb. L., Ool. Sands., Red Sands.
146. Luddendenfoot	1893.	L.D. Volc.
147. Lund	1891.	Gran., Ba., Dior., Sands.
148. Malham	1887.	Carb. Congl.
149. Manfield, near Darlington.	1889.	Fels. Trap (? And.).
150. Market Weighton	1892.	Ool. Sands.
„	1895.	Carb. Sands.
„	1898.	Black Flint.
151. Marton-cum-Grafton	1889.	Shap.
152. Meaux	1901.	Rh. P., Chev. Porph., Carb. L. and S., Lias.
153. Middleton-on-Wolds	1902.	Rh. P., Gran., Ba., Carb. S. and Grit, Chev. Porph., Lias.
154. Mirfield	1893.	Butt.
„	1896.	L.D.V., Butt., Esk., Carb. Grit, Gran. (Not L.D.)
155. Mount Grace	1898.	Shap.
156. Mulgrave Park	1890.	Shap.
157. Muston, near Filey	1888.	Ba., Grit.
„	1889.	Sands., Gran., Ba.
158. Mytholmroyd	1896.	Esk., Butt., Gneiss, ? L.D.V.
„	1902.	L.D. And. Rhy., Butt., Esk.
159. Neswick	1888.	Ba.
„	1889.	Ba.
160. Newbald	1903.	Ba.
161. Newbold	1895.	Gran., Limes.
162. Newby (Scarborough)	1890.	Sands.
163. New Year's Bridge, Denshaw Valley.	1889.	Syen., Dior.
164. Noblethorpe (Cawthorne)	1896.	L.D.V.
165. Norber	1887.	Carb. Congl.
„	1888.	Sil. Grit.
166. North Cave	1895.	Ba.
167. North Dean	1893.	L.D.V., Butt., Gran., Esk.
168. North Ferriby	1896.	Carb. L. Sand. Grit Congl., Lias, Chalk, Ba., Gran., Sch., Gneiss.
169. North Otterington	1888.	Gran.
170. North Stainley	1888.	Carb. Grit.
171. Old Bridlington	1888.	Ba., Sands.
172. Out Newton	1895.	El. Syen., Laurv., Rh. P.
„	1902.	Shap.
173. Patrington	1898.	Ba., Gneiss, Porph., Rb. P., Carb. L. and Sands., Lias, Flint.
174. Peak Station	1899.	Gneiss, Porph., Gran., Ba., Flint, Mag. L., Quartzite, Vein Quartz, ? Sparag, Grit, Trias, M.G., Qz. P., And., Jasp., H. Sch.
„	1900.	Rh. P., Shap.
175. Pickering	1896.	Ool. Lime and Sands.
176. Pickhill	1892.	Ba.
177. Pierce Bridge	1887.	Shap.
178. Preston (Holderness)	1896.	Ba., Carb. Sands.
179. Rainton (N.R.).	1891.	M.G.
180. Redcar to Saltburn	1896.	Carb. L. Sands ,Grit, Mag. L., Lias, Ba.,Gran.
181. Reighton	1888.	Gran., Carb. L.
„	1889.	Ba.
182. Robin Hood's Bay	1887.	Shap.
„	1889.	Carb. L., Shap, Grit, Sands. (? Jur.), Gneiss, Ba., Felstone.
„	1896.	Shap, Sch., Carb. L., Ba., Gran., Gneiss, Armb., Dalb., Gran., Rh. P., Qz. P., Laurv., Porph., M.G., Brock, Mag. L., Tr. Sands., Gyps., Lias, Ool., Flint.
„	1902.	O.R.S. and Jasper, Haggis Rock.

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183.	Rokeby	1892.	Ba.
184.	Rough Ground	1882.	Shap, Carb. L.
185.	Rough Lee (Rendle Water)	1887.	Carb. Congl.
186.	Royston	1895.	Volc. Ash, Chert, Mag. L., Threl., Ba.
187.	Rudstone	1899.	Rh. P.
188.	Runswick	1889.	Gran., Shap.
189.	Runswick Bay	1900.	Shap, Brock., Mag. L.
190.	Ruston Parva	1890.	Dior.
191.	Sand Hutton	1891.	Shap.
192.	Sandle Mere (Holderness)	1903.	Tooth of Mammoth.
193.	Saltburn	1888.	Shap.
	,,	1896.	Ba.
	,,	1897.	Laurv.
194.	Sawley Abbey	1892.	Perm. Congl., Limes.
195.	Scalby	1890.	Ba.
	,,	1898.	Ool. Sands., Carb., Ba., Chalk.
196.	Scarborough	1892.	Ba., Limes., Shap.
	,,	1891.	Ool. Sands.
197.	Scarth Nick	1899.	Ba., L.D.V., Porph.
198.	Scugdale	1899.	Grit, Carb. Chert, Gran., Volc. Ash, Porph.
199.	Seamer	1888.	Gran., Shap., M. Schist.
	,,	1889.	Ba., Sands.
	,,	1890.	Ba., Sands. Ool. Sands., Carb. L., Gran.
	,,	1899.	Ba.
	,,	1900.	Ba.
	,,	1901.	Rh. P., Chev. Porph., Ba., Gran., Mag. L., Carb. L., Flint, Lias.
200.	Seamer Beacon	1900.	Jur. Sands., Chev. Porph., Ba.
201.	Seamer Beacon	1900.	Jur. Sands., Chev. Porph., Ba.
202.	Settrington (V. of P.)	1901.	? Quartzite, Trias, Vein Quartz, Carb. Sands., Jasper, Flint, Ba., Gneiss.
203.	Sinderby	1892.	Carb. L.
204.	Skeffling	1898.	Ba., Gneiss, Porph., Rh. P., Carb. L. and Sand., Lias, Flint.
205.	Skelton Beck	1896.	Whin Sill.
206.	Skidby and Little Weighton	1895.	Ba.
207.	Skinning Grove	1887.	Gran.
208.	Skipsea	1893.	Ba.
209.	Skirlaugh	1896.	Ba.
210.	Sleights	1888.	Gran.
211.	Slippery Foot, Keighley	1903.	Ash (Borr.).
212.	Smalley Bight	1893.	L.D.V
213.	Sneaton	1896.	Shap.
214.	Southburn, near Driffield	1899.	Ba.
215.	Southburn (Kirkburn)	1890.	Ba.
216.	South Cave	1895.	Limes.
217.	Sowerby Bridge	1893.	L.D. Volc.
	,,	1902.	Carb. Sands.
218.	Speeton	1888	Ba., Sands.
	,,	1890.	Sands., Ba., Shap, Carb. L., Gran., M. Sch., Red Sands., L. Lias, Ool. Irons.
	,,	1899.	Rh. P., Sil.
	,,	1900.	Shap.
219.	Sprotborough	1897.	Shap, Orth. Porph., Dior., Ba., Carb. Grit, Carb. L., Gran.
220.	Staintondale	1890.	Shap.
221.	Staithes	1897.	Rh. P.
222.	Stanghow	1899.	Shap.
223.	Stanley	1893.	Esk., L.D.V.
224.	Startforth	1892.	Shap, Grey Gran.
225.	Staveley	1889.	Sands., Carb. L., Shap.
226.	Staxton (Scarborough)	1889.	Carb. L., Ba.
227.	Stillington	1888.	Limes.

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228.	Stonegate	1899.	? Sparag., Porph., Ba., Gran., Quartz Porph., And., Carb. Chert L. Basement, M.G., Flint, Jasper, Red Sands., ? Old Red S., Gneiss, H. Sch., Quartzite, Vein Quartz, U. Lias, Mag. L., M. Lias.
	,,	1902.	Queensbury Grit, H.
229.	Stonegate, Eskdale	1903.	Syenitic Dyke-rock (Norw.).
230.	Stonehouse	1896.	Gran.
231.	Strensall	1889.	Sands., Ba.
232.	Strinesdale (Oldham W.W.)	1899.	Sil. Grit, Syenites, L.D. (prob. Butt.), Carb. L.B., Quartzite, 'Trap.'
233.	Stump Howe, near Whitby	1900.	Rh. P.
234.	Sutton-on-Hull	1895.	Ba., Carb. L., L. Lias, Gran.
235.	Swanland	1896.	Gran., Ba., Sands.
236.	Swine	1895.	Ba., M.G., Carb. L.
237.	Tanfield	1893.	Shap.
238.	Teeside	1892.	Shap, Armboth, Carrock.
239.	Thirkle Bridge (Holderness)	1903.	Dol.
240.	Thirley, Cloughton	1900.	Jur. Sands.
241.	Thirsk	1903.	Gabb. (Carr.), Porph. (Chev.), Gran., Ool., Carb. Congl., Shap.
242.	Thornborough (W. Tanf.)	1889.	Grit.
243.	Thornes	1893.	Esk., Butt., L.D.V., Vein Quartz.
244.	Thornton Dale (V. of P.)	1901.	Ool.
245.	Thornton-le-Beans	1888.	Shap.
246.	Thornton-le-Clay	1889.	Carb. L. and S., Ba., Sands., Gran., Lias.
247.	Thornton-le-Moor	1888.	Gran., Ba., ? Ash.
248.	Thornwick Bay	1899.	Laurv.
249.	Todmorden	1896.	L.D.V.
250.	Topcliffe	1893.	M.G.
251.	Upper Foot	1896.	L.D.V.
252.	Upsal	1903.	Gabb. (Carr.), Gran. (? Chev.), Dol., M.G., Carb. L.
253.	Wakefield	1892.	Butt., Gran.
	,,	1893.	Esk., L.D.V.
254.	Wassand (Hornsea)	1898.	Ba.
255.	Wath (N. Riding)	1890.	
256.	Wawne	1902.	Laurv., Rh. P., Ba., Greywacke, Chev. P., Flint.
257.	Weeton	1898.	Ba., Gneiss, Porph, Rh. P., Carb. L. and Sands., Lias, Flint.
258.	Welwick	1898.	Ditto.
259.	West Rigg (Lockwood)	1899.	Flint, Porph, ? Sparag., Quartzite, Grit, And., Carb., Chert, Sch., Gran., Rh. P.
260.	West Tanfield	1889.	Carb. L.
261.	Wetwang	1903.	Quartz.
262.	Washton (Bourn Cas)	1897.	Shap.
263.	Wheatcroft, near Scarborough.	1900.	Shap.
264.	Whitby	1889.	Carb. L., Shap.
	,,	1899.	El. Syen., Dolerite.
	,,	1900.	Jur. Sands., Mag. L., Carb. L., Ba., ? Sparag., Jasp., M. and L. Lias.
	,,	1902.	L.O.R.S., Ba.
265.	Whorlton	1887.	Gran.
266.	Wighill, near Tadcaster	1901.	Ba., Chert.
	,, ,,	1903.	Whin Sill.
267.	Willerby, near Hull	1898.	Carb. L. Sands., Ba., Jur., Gran., Gneiss, Rh. P., Black Flint, *Bel. lanceolata*, L. Lias.
268.	Winestead	1890.	Ba., Carb. L.
	,,	1892.	Carb. L.
269.	Winterbut Lee	1896.	Gran., Quartzite.
270.	Withernsea	1898.	Shap, Blue Gneiss, *Bel. lanceolata*, Black Flint.

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271.	Wykeham	1901.	Ba., Chev. Porph. and And., Flint, El. Syen., Lias.
	„	1902.	Flint.
	„	1903.	Whin Sill.
272.	Yedmandale, near W. Ayton.	1899.	Rh. P.
	„ „	1900.	Chev. Porph., Greywacke, Jasper, Gran.
273.	York	1888.	Shap, Limes., Est. Sands., Carb. L., Jur. Sands. and Limes., And.
	„	1889.	Carb. L.
	„	1893.	M.G.
	„	1901.	Carb. Sands.
274.	Youlthorpe, near Stamford Bridge.	1888.	Sands.

Observations on Changes in the Sea Coast of the United Kingdom.—*Report of the Committee, consisting of* Sir ARCHIBALD GEIKIE, Captain E. W. CREAK, Mr. L. F. VERNON-HARCOURT, Mr. A. T. WALMISLEY, Mr. W. WHITAKER, *and the* GENERAL OFFICERS, *appointed by the Council.*

[PLATE IX.]

IN 1898 the following resolution was referred by the General Committee of the British Association to the Council for consideration and action if desirable :—

'That the Council be requested to bring under the notice of the Admiralty the importance of securing systematic observations upon the Erosion of the Sea Coast of the United Kingdom, and that the co-operation of the Coastguards might be profitably secured for this purpose.'

On the recommendation of a Committee of the Council appointed to consider the above resolution, the Council decided to inquire whether the Admiralty would be willing to arrange that observations of a simple character on changes in the sea coast be recorded and reported by the Coastguards. A favourable answer having been received from the Lords of the Admiralty, the Committee, at the request of the Council, proceeded to draw up suitable forms on which to make the reports and a scheme of instructions to guide the observers in recording their observations. A supply of these forms with instructions was then forwarded to their Lordships, and issued by them to the Coastguards in 1899. Since that date forms, duly filled in, have been received regularly from the Coastguard stations of the United Kingdom and filed in the offices of the Association in Burlington House.

The observations having accumulated to an extent sufficient to justify an attempt being made this year to tabulate them, the present Committee, having been appointed to superintend and direct the work, with the consent of the Council, obtained the services of Mr. John Parkinson, B.A., of St. John's College, Cambridge, to collate the data in hand. Mr. Parkinson has devoted himself with much ability and zeal to the somewhat laborious task he undertook, and has prepared a most valuable report and map which the Committee are pleased to incorporate in their report to the Council.

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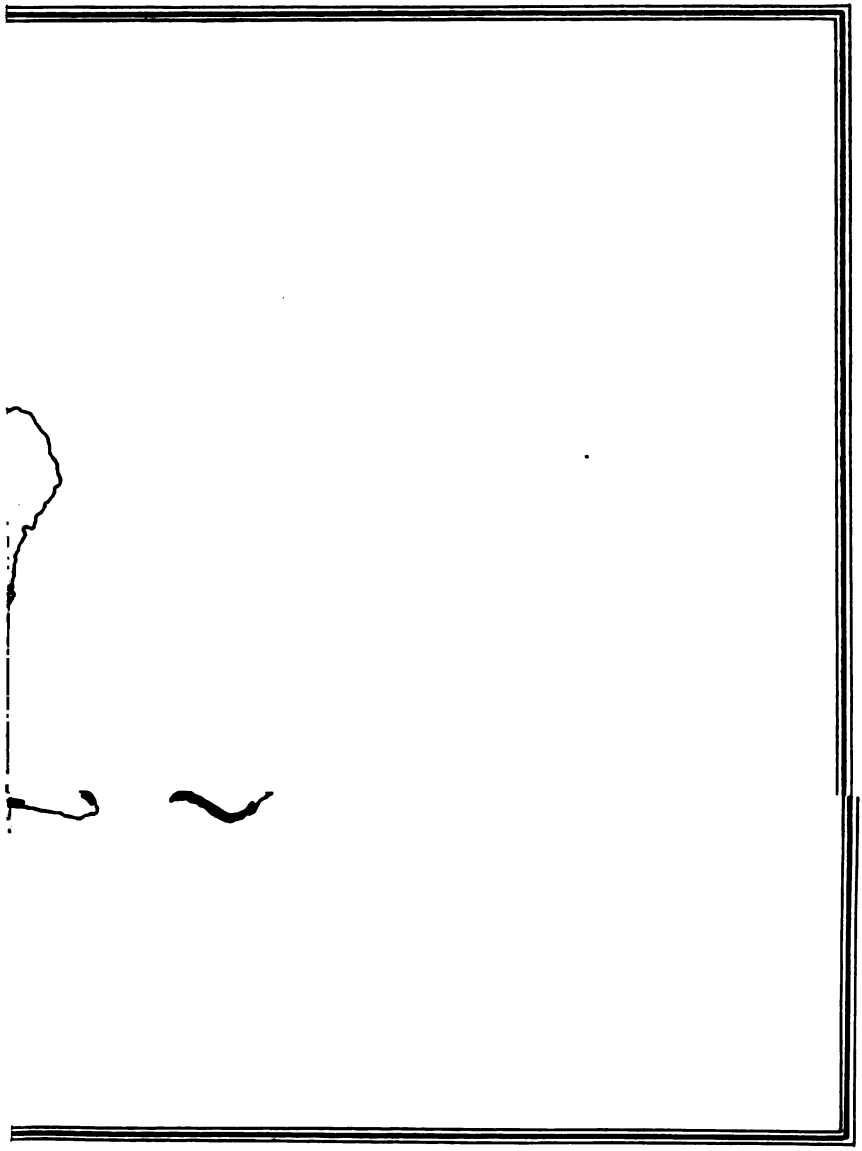

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The Committee recommend that their report be communicated to the Geological Section at the Southport meeting of the Association, and that it be published in the Annual Report.

The Committee further recommend that copies of the report be sent to the Admiralty, that their Lordships be informed of the valuable and important information which has been obtained through their assistance and co-operation, and that an offer be made to forward to them copies of the report for distribution to the Coastguard stations if considered desirable.

In conclusion the Committee consider that the best thanks of the Council are due to Mr. Parkinson for his report and to the various officers in the Coastguard Service who have furnished the information upon which it is based.

Report to the Committee by JOHN PARKINSON.

The observations on which this report is based were sent to the British Association by the Coastguards on forms supplied to them. These forms were of two kinds. No. I. when filled in gives information as to the nature of the coast reported on, the vertical range of ordinary spring tides, the evidence for encroachment of the sea or for gain of the land, the artificial causes influencing natural changes and details concerning the removal of shingle, &c. Form II. is used to record any changes of especial interest, such as falls of cliff or the erection of new groynes.

In this summary the observations are treated in order round the coast, beginning with the county of Wigtown and following on from point to point in the direction taken by the hands of a watch. Ireland is treated last, the same arrangement being adopted, beginning at Galway Bay.

SCOTLAND.

The reports received from *Scotland*—forty-eight in all—are for the most part confined to the eastern coast; the western, including the Hebrides, being unrepresented as far south as the mouth of the Clyde.

The distribution of the reports in the maritime counties and adjacent islands is as follows:—Wigtown, 5; Ayr, 3; I. of Arran, 2; I. of Bute, 1; Renfrew, 1; Orkney Isles, 2; Shetlands, 1; Caithness, 2; Eastern Sutherland, 1; Eastern Cromarty, 1; Eastern Inverness, 1; Elgin, 3; Banff, 1; Aberdeen, 5; Kincardine, 6; Forfar, 5; Fife, 5; Haddington, 2; Berwick, 1.

The following alterations are recorded:—

Some encroachment of the sea takes place in the neighbourhood of Stranraer. Concrete walls now protect an endangered road; a breakwater, piles, &c. have been built at the head of the loch and groynes erected at Broadstone (1¼ miles N.W. of Stranraer).

No other change is on record until we reach the eastern coast of Sutherland, where at Helmsdale, behind the west pier, there has been some loss of land. This is now partially stayed by a breastwork of wooden piles. No gravel is removed. In Banff a slight loss occurs to the east of Portsoy Harbour, and stones &c. are constantly removed.

The southern part of the Kincardine coast suffers loss in two adjacent places: first at Gourdon through the shingle being removed for industrial purposes, and the absence of groynes; second in the neighbourhood of Johnshaven, where the loss occurs about 300 yards south of the

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C.G.S. and between East and West 'Mathers,' on the Lawrencekirk estate The damage is done by south-easterly winds and spring tides, and a short wall, 60 feet long, has been built 300 yards south of Johnshaven to save the land. No shingle is removed.

Part of the sandy shore has been removed by the sea between East and West Haven, Carnoustie (Forfar). There are no groynes, and beach material is occasionally removed by the permission of the factor of the estate.

The cliffs in certain parts of St. Andrews Bay are being worn away by the sea, and near the town have to be supported by masonry and concrete walls. Within the past three years several cases of landslip are recorded. As before no groynes have been built, and material is taken from the east sands by contractors for building purposes.

The only gain in land from the Scottish coast is reported from Burntisland owing to the accumulation of sandbanks on the foreshore; much sand is dredged for the construction of the new docks.

Finally, in the counties of Haddington and Berwick, from Pefferburn to St. Abb's Head, a distance of 29 miles, a loss of cliff takes place at spring tides with north-easterly gales. The coast is unprotected, and no shingle &c. is removed.

England.

From St. Abb's Head to Saltburn.

The changes on this coast appear to be insignificant, but losses are recorded in the neighbourhood and to the north of Hartlepool, near Shields, and on the northern side of Blyth, the latter part being now protected. On the other hand, small gains of land are reported from Holy Island Sands and St. Gan Breakwater, Redcar. As regards the coast-protections Berwick is shielded by a pier, while Newliggin and Cresswell (Wansbeck Road to Chevington Burn) are groyned. South of this section the list of coast-protections given in the returns apparently understates the truth, nothing of the kind being mentioned from Tynemouth and South Shields. The northern side of Blyth Harbour is protected by a wall, and piers have been built at Sunderland and Hartlepool. At the latter town the sea- and dock-walls have a tendency to keep the sand in the bay. The concrete pier erected at Skinningrove is said not to affect the beach.

Sand is removed from Berwick, Bamburgh, the Amble and Hauxley district (Alnmouth), from the neighbourhood of North Shields (from Brier Dene Burn to Low Light), Sunderland, and the north of Seaham, and from Saltburn. On the contrary it is not removed from the ten miles of coast between Wansbeck River and Brier Dene Burn (Blyth Haven) from S. Shields to Souter Point, and from Seaham Harbour and Hawthorn Hive.

The Yorkshire Coast south of Saltburn.

For the stretch of coast between *Saltburn and Scarborough Bay* no returns have been received, but for the important district between *Filey Point and Spurn Head* the records are complete, and the following may be taken as a general summary.

Between Filey Point and Flamborough Head the coast line is practically stationary, except in Filey Bay, from Filey Brig to the King and Queen Rocks at Speeton, where the average loss for some twenty-eight years is about 3 feet per annum. On the southern side of Flamborough Head the

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rate of erosion is about the same. The town of Filey is protected by a sea-wall. No groynes exist at Speeton, and shingle and sand are being constantly removed during the winter months; but on the southern side of Flamborough Head (at Sands Road), one groyne has been built which retains the beach sufficiently to enable carts to get down to and to remove the sand. This loss is stated to have no apparent effect. At Bridlington Quay parades and a sea-wall prevent subsidence to the north and south of Bridlington Harbour, where there was formerly an annual loss of about six feet. Piles are driven in close to the sea-wall, and groynes prevent the scour of the beach and retard the travelling sand and shingle. To the north of Wilsthorpe Gap groynes protect the beach, but do not prevent subsidence of the cliff. At Flamborough Head, Bridlington Bay, fresh-water springs cause the initial slipping of the cliff. The Divisional Officer, writing from Bridlington Quay concerning the coast from $3\frac{1}{2}$ miles north of Filey Brig to Grimston Garth, 9 miles south of Hornsea, states that shingle, sand, and stones are removed from most places, except from Atwick Gap to Garton Gap, where the beach is protected by order of the Board of Trade. Along this coast, from Bridlington Quay to Spurn Head, practically the whole coast is receding at an average rate of 6 feet per annum, where not especially protected, as in Bridlington Harbour.

Groynes exist at Hornsea, both to the north and south of the village, and keep the shingle in place; elsewhere the loss appears to be between 3 and 4 feet per annum. At Withernsea groynes in a very bad state of repair are placed 100 yards apart, but the average annual loss is 9 feet per annum. Shingle is not removed. At Sandlemere and Hompton an annual loss of 9 feet per annum is also recorded.

From Kilnsea Warren to Spurn Point, a distance of 4 miles, groynes retain and build up a good beach; nevertheless the annual loss is given as 6 feet. Three observations of definite change witnessed have been supplied on Form II. The first relates to a large fall of clay in June 1899 at Pampletine Cliff, Filey. The mass was 60 yards in length by 9 yards in breadth, having a depth of some 100 feet. Such slips, which are not uncommon, are produced, not merely by the encroachment of the sea, but also through heavy rains and springs. At Ulrome (between Hornby Runnell and Atwick) about 15 feet of cliff disappeared in 1899; the average annual rate is estimated at 6 feet. The cause is locally attributed to the scarcity of sand at the base of the cliff; and it is noted that the loss is greatest where the cliffs are highest.

An undated report (probably 1899–1900) from Kilnsea records a very rapid loss of land. In two months these slips reached the extent of 50 yards inland and 100 yards in length, and occurred at intervals along some five miles of coast. Additional information, received in July 1903, from Withernsea states that a large quantity of cliff has been washed away since 1899 or 1900 from Wareholme, Garton, and Dimlington.

The shingle is not removed from Hornsea to Kilnsea.

The Humber Estuary.

The records for the *Estuary of the Humber* are also fairly complete up to and beyond Barton. On the northern bank Cherry Cob Sands and Sunk Island Sands show slight gains, due to the building of five chalkstone groynes. On the southern bank, the more northerly part of Cleethorpes shows some gain: it is protected by a sea wall and groynes.

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Also at Tetney Haven, to the south of Cleethorpes, sediment is deposited upon the foreshore for an area of some 2½ miles in length and ½ mile in width at spring tides. The observations extend as far south as Northcotes Point. The low and muddy shores of Marfleet and Paull, on the northern bank, show no change, but variable erosion is reported from Barton and Killingholme, where the shore is unprotected, and on the southern shore of Cleethorpes through heavy gales. Nearly all the southern bank of the estuary is protected by sea-walls or groynes. At Killingholme the clay banks, their summits 6 or 8 feet above the beach, are covered, more or less completely, by an apron of chalk and ironstone. A shingle bank is said to be accumulating on the northern shore of South Killingholme Haven, and a large sandbank in the river between North Terriby and Hessle. In the neighbourhood of Terriby Hall, Barton Cliff, and Barton Ness (Barton-on-Humber) the recorded loss is from 4 to 6 feet in 2½ years. Small groynes have been built from the Rifle Butts (3 miles west of Hull) to North Terriby, but are said to have no effect on the beach. Docks and piers occupy part of the bank between Barrow Haven and Chalk Point, and stones have been deposited to protect the banks near Barton Cliffs. Apparently erosion in the estuary of the Humber is not very serious, for (in July 1903) the loss of land at Barton-on-Humber is said to have been imperceptible since 1899, while at Killingholme no change has been recorded in the same time. At Cleethorpes, however, about 20 feet of bank have been washed away in this period; but the sea-wall is now being extended for ¾ mile E.S.E. to protect the part in question.

Lincolnshire and the Wash.

Along the *remainder of the Lincolnshire coast, the borders of the Wash,* and *the Norfolk coast as far east as Salthouse at Lower Sheringham* the losses of land are also insignificant. From Northcotes Point (south of the Humber estuary) as far south as Ingoldmells Point losses occur at Sutton-le-Marsh and Chapel St. Leonards. Elsewhere the coast-line is stationary. At Anderby there are no groynes and the shore is fringed with sandhills covered by gorse and grass; while from Theddlethorpe northwards it is protected by groynes at intervals. At Chapel parts of the sandbank are washed away during each winter, but the shore is protected by groynes and faggots, which help to make up the banks. No sand is removed for any purpose. In the neighbourhood of Sutton and Mablethorpe the low sandy beach suffers a similar loss, and the shore, moreover, is unprotected by groynes. As at Chapel, no sand or shingle is allowed to be removed.

On the remaining Lincolnshire coast, and that of Norfolk as far as Salthouse, but one loss is on record—viz. between Old and New Hunstanton. The contrary is the case in many parts of the Wash; thus from Lynn Cut to Wooten Creek the sea has apparently been receding during the last five years, and land once under water is now covered only by high spring tides. Banks are built to keep back the sea and reclaim the land for cultivation. The same system is adopted east of Sutton Bridge (near mouth of the river Nene), where the last inclosure (1899) was made in 1865. From the south point of Fleethaven to the Lighthouse (river Nene), Drove End detachment C.G.S., the land is reported to be gaining on the sea. It is protected by banks near Freiston and Butterwick on the western side of the Wash. At Ingoldmells C.G.S piers

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tend to keep the sand and shingle up to the banks. Beach material (or mud locally) is removed from the neighbourhood of Ingoldisthorpe, the river Witham, and Skegness. The low coast of the last-named place is unprotected by groynes.

East Anglia.

Entering *the East Anglian coast* at Salthouse we find an almost continuous record of erosion as far south as Harwich. But four gains of land are recorded and but one stationary coast-section (Sizewell). Taking the gains of land first, we note that a local increase is recorded opposite the C.G.S. at Winterton; and at North Yarmouth, where the increase is supposed to arise from the piers and jetty stopping the shingle travelling from the north. The third locality which shows a gain is the coast to the north of Orford Ness, and that without the aid of groynes, while the fourth and most southerly is on the eastern bank of the river Deben. On the western side of the river the sea is encroaching. The gain at Winterton appears to be purely local; since both to the north and south of the C.G.S. losses occur in spite of three groynes to the north of the station.

Losses are reported from all other stations (nineteen in number), with the exception mentioned above at Sizewell, where the coast line is said to be stationary. The erosion necessarily varies greatly from point to point, but may be taken as from 6 feet to 9 feet per annum. An exceptional case is that of the Low Lighthouse on Lowestoft Ness, which has been moved back 249 feet in consequence of a loss to the headland on which it stood of 120 feet in the year (probably 1899). Out of twenty-four coast-guard stations sixteen are reported as being protected by groynes; the exceptions are Orford Ness and to the north, the coast south of Great Yarmouth, and north of Happisburgh.

Shingle is removed from twelve stations along the coast, Sheringham, Cromer (by Lords of the Manor and Urban District Council), Mundesley, Bacton, and Happisburgh (above high-water mark), Winterton (in quantity), Caister (except between Scratby and the lifeboat house, Caister), N. Yarmouth, Gorleston, Thorpe (in small quantities), Orford Haven, and Felixstowe (between Beach Station Road and Martello Tower Q).

Taking the various stations in order, the following details may be noted as being of interest. Information from Weybourne (Clay Sluice to Sparrow Gap) is that 'most of the shingle beach for a quarter of a mile to the west of the station was washed away, but is now coming back, while 6 yards of cliff have been washed away to the eastward of the station during the eight years the present occupier has been in charge' [up to July 1903]. At Sheringham six groynes exist, and have made an improvement in the beach, and a sea-wall is under construction. At Cromer the coast is protected by six permanent or pile-driven groynes and twenty-four Case groynes. Occasional large landslips and frequent small landslips occur. Several important ones are recorded in 1899, 1901, and 1902 along the coast from Runton to Sidestrand: they varied from 100 to 160 yards in length and 18 to 70 yards in depth. Eight wooden groynes have been built at Mundesley, by which the shingle is at times retarded, but at others it is scoured away. Several falls of cliff have taken place since 1899. At Cox's Point the sea is said to have gained 20 yards since that date, and the annual loss over about five miles of coast is estimated at 5 yards.

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At Happisburgh the groynes put down in 1893 were carried away by gales in 1895, and the annual loss is estimated at 9 feet; but the writer was informed in July 1903 that the yearly loss between Harboro' Gap and Ostend Gap is about a foot.

Five groynes have been placed 'near Eccles steeple,' and prevent the beach from scouring away, while ridges of thorns are placed in trenches at the foot of the sandhills. The average height of these hills is 15 feet. Since 1899 an encroachment of 8 to 12 feet has taken place between Eccles Point and Horsey Gap, the greatest loss being at Eccles Beach.

For one mile north of Winterton Ness there has been an annual loss of about 6 feet, with 'a corresponding gain to the south of that point.'

A similar loss is recorded between California and Caister Points, but groynes erected by the Midland Railway Company 1½ mile north of Caister have there caused an increase of sand and shingle.

The cliff north of Baker's Score at the end of Corton village sustains an annual loss of 3 feet, but erosion is prevented south of this point by Mr. Colman's defences. North-easterly winds appear to be very destructive to this coast (and also easterly and south-easterly), since by removing the beach they allow the tide to get close up to the cliff. With westerly winds the sand again makes up to the depth of 4 or 5 feet.

Between 1899 and 1903 about 50 yards of land have been washed away from Pakefield Cliff for the length of a mile; but opposite the coastguard station (at Lowestoft) a gain of 20 yards has taken place for a length of some 600 yards. A report, dated February 1900, remarks that the footpath has been lost between the lighthouse and the R.N.R. battery through high tide and wind. The heavy loss on Lowestoft Ness has been referred to above. From Kessingland C.G.S. an outline of the coast has been forwarded (from Pakefield Gap to Covehithe, a distance of about 6 miles) contrasted with its appearance fifty years ago, *i.e.* in 1849. During that time the shore has receded nearly 1,200 feet to the north of Kessingland Church and at Covehithe.

Around Southwold an encroachment of 30 to 40 feet has taken place since 1899, giving an average yearly loss of 10 or 12 feet from Covehithe to Dunwich (6½ miles); and in a report of earlier date the estimate is still higher. From 500 yards north to 500 yards south of Thorpe C.G.S. the sea has encroached (August 1899) 150 feet since 1882; a northerly wind greatly increases the height of the tide, and there are no groynes or other protection. Between East Lane C.G.S., Bawdsey, and Woodbridge Haven there has been a yearly loss since February 1900 of about 15 feet, applicable to 1½ mile of coast. Groynes have been built locally. Between Felixstowe Pier and Felixstowe Point (2¾ miles) the coast gains through being groyned. North-easterly winds tend to wash the beach to the southern side of the groynes, south-westerly to the northern. A southerly wind tends to make the beach, a northerly having the contrary effect.

Groynes have been built at intervals along the Sheringham, Cromer, Overstrand, Mundesley stretch of coast. As above mentioned, they existed formerly at Happisburgh; while allusion has been made to those built at Eccles, Winterton, and Caister. Immediately to the south of Great Yarmouth the coast is unprotected; but groynes have been constructed locally between Gorleston and Corton. Lowestoft and Southwold have certain coast-defences; the south beach at the former place has a system of Case groynes; and thirty have been constructed at Southwold, where they are stated to have a good effect.

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The Kessingland and Dunwich coasts are unprotected, and no beach is removed with the exception mentioned below. At Coney Hill, near Misner Haven, one groyne has been placed; here also nothing is taken away for industrial or other purposes. Southwards groynes have not been erected; but Orford Haven is partly groyned, as is the coast from Bawdsey to Woodbridge Haven. The effect is to collect the shingle, of which none is taken away.

At Felixstowe (to the entrance to Harwich Harbour) a sea wall was in course of erection in August 1899, a few yards above H.W.M.O.S.T., between Landguard Lodge and Beach Station Road. Between Towers Q and R (and also extending round Felixstowe Point) groynes have been constructed; but these were partly washed away during heavy weather. The effect of the wind on the beach has been already noticed.

Two reports have been received relative to the erection of new coast defences. At Cromer these refer to the extension of the pier and the promenades; at Bacton to the building of a sea-wall of concrete between Walcott and Ostend Gaps (report received in June 1899). Especial mention should be made of the large quantity of shingle removed (February 1900) from above high-water mark along the coast 50 yards north of Dunwich. This has been done by order of the Blything Rural District Council.

Essex.

Concerning the coast from *Harwich to the Roach River*, observations from thirteen stations provide evidence of little change, since ten record no alteration—a result no doubt of the artificial protections.

A gain is reported from Walton-on-the-Naze following the lengthening of the pier, and a loss from near Harwich Harbour, where the sea-wall is broken in, with local slips at Clacton at unguarded spots. Every station is protected, usually with sea walls; while Harwich, Walton, Clacton, and the eastern side of Mersea Island are provided with groynes. Shingle is removed in small quantities from Harwich, Clacton, Colne Point, and from the southern side of the Blackwater River.

Kent and East Sussex.

The next reports are sent from the mouth of the Medway, and we may consider *the Kentish together with the Sussex coast as far west as Goring, near Worthing.* (Sheet 20 and 24 of the 4 miles=1 inch map.)

We have to deal with seventy-three observations, amongst which six gains of land are recorded.

Taking these first, a gain of 60 feet in seven or eight years is reported from Walmer, and from Kingston in the same neighbourhood (south of Deal). The beach also accumulates between Littlestone and Greatstone, and southwards almost to the point of Dungeness; indeed Littlestone Point is said to have lengthened out 100 to 150 yards in the last three years (up to 1899). This report, dated from Romney C.G.S., records that 'the whole of the Hoy has been, and the mouth of the Hoy is now, thickly faggoted in square patches representing small square fields, which by accumulating mud and sand are gradually filling up the Hoy to nearly tide level.'

Gains occur at Rye Harbour, Newhaven Harbour (insignificant), and at New Shoreham. The first place is protected by groynes and a sea-wall.

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On the western side flints are collected and sent to Stafford for the manufacture of pottery, and sand and gravel are removed for making concrete and for building purposes. At Shoreham groynes have been placed 1½ mile west of the harbour, and accumulate the shingle &c.

Comparing the erosion which occurs on the various parts of the Kentish coast, it would appear that the northern shore is the greatest sufferer, the amount of erosion decreasing in passing from the eastern to the southern coast and the borders of Sussex. Omitting those localities where the shingle gains, and also those where there is a loss in one place and a gain at another, as in parts of Rye Bay, the relative losses on the three parts of the coast may be roughly expressed by the figures 61, 59, and 54, these representing percentages of loss on the total number of observations.

As before, various points of interest will be noticed in sequence in passing round the coast. In the parish of Minster, Sheppey, about two acres of cliff fell in January 1903, half way between the Coastguard Flagstaff and Bell Farm.

Eastward very little change is reported from Whitstable since 1899, except for a slight increase of shingle near the old coastguard buildings at Swale Cliff, with, however, a considerable loss near the new station, where in May 1903 about an acre fell, and the whole edge is reported as seeming to be in a crumbling condition.

At Herne Bay, from Hampton west of the old pier to Hampton Point, a distance of a mile, a report dated July 1903 records falls of cliff owing to the beach being scoured away. Near Hampton the yearly loss has been 15 to 20 yards, but gradually less northward for the remainder of the cliff. Moreover, the loss of land increases rapidly each year. Hampton Pier causes a scour to the west, but collects the shingle on its eastern side. To the west of this pier four Case groynes have been erected to protect the cliff.

Frequent slips and falls of cliff occur at Reculvers during the rainy season after a long period of dry weather or when a thaw sets in after a frost. No important changes are reported since 1899 between Cold Harbour on the east and Beltinge Lane on the west, but the cliff between Reculvers and Herne Bay loses about 4 feet per annum. Groynes have been erected by the High Commissioner of Sewers, by Mr. A. Collard and Miss A. Monckton. For a mile W.S.W. of Birchington Station towards Reculvers the average yearly loss through falls of the cliff has been 6 feet. At the termination of the cliff groynes are placed, and cause a large accumulation of shingle which is not removed.

From the east end of Margate to the North Foreland the annual loss of land is about one-tenth of an acre, for heavy falls of the chalk cliff take place in wet or frosty weather.

From the North Foreland to Dumpton Gap (Broadstairs C.G.S.) four falls of cliff took place in 1901, and three in 1903, the average yearly loss since 1899 being about one-fifth of a foot. For one mile south of the coastguard station at No. 2 Battery, Deal, the annual loss is 12½ feet. South of this again the coast is stationary, while at Kingsdown, as above mentioned, the beach is 'making' to the north of the station. To the south, however, the loss has been heavy. A carriage drive formerly existing south of this station to St. Margaret's Bay is now destroyed, although a margin of 50 yards of land lay once on its seaward side. At high spring tides the sea now reaches the base of the cliffs. To the north of the coastguard station shingle is removed in large quantities.

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The losses of cliff at St. Margaret's Bay form the subject of a number of reports on Form II. In February 1900 between 400 and 500 tons of chalk fell from the western end of the bay; in March of the following year the sea made breaches in the foreshore; while in December two falls are reported of 100 and 500 tons, the first one mile N.E. of the bay, the second half a mile S.W. of South Foreland High Light. In February of 1902 800 tons of chalk fell from the cliff 200 yards east of Cornhill C.G.S., while in November and December of the following year a fall of 100 tons of chalk took place about one mile north of the bay, and one of 1,500 tons from 'Fan Bay,' 600 yards east of Cornhill C.G.S. In March of the same year (1903) the sea, aided by a strong wind from the N.N.W., cut into the foreshore between North Point and Ness Point at various places; some of the hollows thus formed were 100 feet in length with a width of 30 to 50 feet.

At Black Rock (the eastern end of Dover Parade) the sea has encroached about 40 feet in the space of twenty years. The works at Dover, now nearing completion (July 1899), are probably the cause of certain alterations in the beach. Thus in the winter of 1898 the shingle was taken away by the sea from a point 600 to 700 yards east of the Promenade Pier and collected at the western extreme. The Dover Harbour Board are placing two new groynes with the intention of recovering it.

At Sandgate extensive damage has been done to the foreshore and sea-wall during the ten years from 1899. Groynes have been built and act favourably in retaining the beach.

Near Hythe the tram lines near the old Lifeboat House have been undermined, and No. 17 Martello Tower is considered to be dangerous for the same reason.

To the S.W. the coastguard station at St. Mary's has been given up by reason of the encroachment of the sea. Here the groynes are reported to have but little effect on the travelling shingle, although a temporary accumulation of sand may be produced in the summer. The heads of these groynes 'are a long way from the beach,' and the east winds carry the shingle on towards Dungeness or Greatstone Point.

The coast around Dungeness is of considerable interest. As above mentioned, gains are reported on the lee side, *i.e.* to the north of the head, for some 6 miles; but at the point itself and to the W.S.W. variable conditions obtain. During the months of January and February 1899 'about 12 yards of beach inland' were washed away by the sea: the exact position is not stated, but presumably from the western side. A report, dated July 1903, records an average gain to the shore at the Point of about 12 or 15 feet per annum, with, however, losses to the westward of about 4 to 6 feet, the district included being from Dungeness Point to three miles westward. It is worth remarking that two new lighthouses are being built. From 1½ to 3 miles west of Dungeness lighthouse the average loss to the coast is 3 feet per annum (1903), an earlier observer remarking that the 'former Hope and Anchor Inn is now on fold of beach, and extraordinary spring tides wash the base.' A few groynes have been constructed to protect the sluice that drains Dengemarsh, and in 1902 a new groyne was laid down at Dengemarsh Gut.

To the north-east of Hastings, at Haddocks, Fairlight, and Ecclesbourne, falls of cliff are frequent, and at Bexhill information gathered from a member of the coastguard who has known this part of the coast

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from 1857 states considerable encroachments of the sea from the date mentioned to 1899. It is reported, in addition, that the groynes laid down as far as Clynde Arch have no apparent effect on the beach, but removal of the shingle, formerly allowed, is now discontinued.

Loss of the cliff is reported from Birling Gap on the western side of Beachy Head, and at Crowlink the cliff is slowly but constantly crumbling. A slight encroachment is noted at Cuckmere owing to groynes having been constructed at Seaford, 3 miles to the westward, and the mouth of Cuckmere Haven, recently closed, is now again open owing to the continual shifting of the beach. Very little material is removed. From the west end of Seaford Parade for three quarters of a mile westward the estimated loss is 4 feet per annum, but a slight gain occurs from 400 yards west of the Buckle Inn to Newhaven Harbour. At Newhaven itself falls of cliff are frequent, and the large breakwater on the western side of the entrance to the harbour stops the shingle travelling eastward.

Passing on to Brighton, it is noteworthy that the groynes along the sea front retard the shingle from working east, and by this means the cliff from the Aquarium eastwards to Roedean is laid bare. This cliff constantly crumbles away with high winds and spring tides. Two wooden groynes at the eastern end of Rottingdean Gap prevent the shingle working eastwards with south-westerly gales. Wooden and stone groynes have been constructed at Hove and Southwick.

The loss at Goring is suggested to be owing to defective groynes, and in the winter a few years ago about 70 yards of a field adjoining the coast were washed away during high spring tides. In this parish no beach material is removed.

Other Coast-protections.—The northern coast of Kent is, on the whole, well protected with groynes, and locally by sea-walls. In the Isles of Grain and Sheppey five stations out of seven are protected by groynes or a sea-wall, or by both. From Whitstable Bay to Margate every station is more or less protected, although losses are mentioned in almost every report. At Westgate, since 1899, a slipway has been built and a groyne run out to protect the new promenade; also the five groynes in St. Mildred's Bay are now completed. The cliff around Foreness Point and the North Foreland is unprotected by groynes, while those existing at the back of the harbour at Broadstairs and at St. Margaret's Bay are said to have no effect on the shingle or sand. It is noteworthy, however, that flints and sand are taken away from the beach for building purposes. The groynes laid down at the northern end of Deal are causing the shingle to shift further north. These groynes (apparently the same), put down north of the pier in 1898, retain the shingle and sand, but are liable to be scoured out by the set of the sea after north-westerly to north-easterly or south-westerly gales.

From Dover to Littlestone (New Romney) reports from eight stations have been received covering the entire stretch of coast. In each case protection by groynes, faggots, or piers has been afforded, and in six out of the eight instances these are effective in accumulating shingle. The alterations in the harbour works at Dover render any precise determination difficult in that locality, while the groynes at St. Mary's have been already mentioned. From Littlestone round Dungeness Point, as far as the eastern side of Rye Harbour, five stations out of seven are protected. Of the remaining two the one situated immediately north of Dungeness Point shows a gain, the other to the south and west a loss. This loss,

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as above noted, is continued westward, and it is noteworthy that the groynes are few. Eight out of thirteen reports covering the coast from Rye Harbour to the northern part of Eastbourne mention shore-protections which it would seem are effective, with the exception noted above from Bexhill.

The remainder of the coast included in this section of the report, viz. from Beachy Head to Goring, has been the subject of fifteen reports, of which ten record the building of groynes or of a sea-wall. Some of these have been already mentioned; in the others the groynes appear to be fairly effective in accumulating and retaining the shingle and sand at the places where they have been erected.

Beach material is definitely stated to be taken from the following places:—

The Isle of Grain.
The western side of Sheerness.
Westgate-on-Sea.
The neighbourhood of Margate, Broadstairs, and Ramsgate.
Kingsdown.
Dover (for building sea-wall under Shakespeare's Cliff).
The foreshore at Folkestone.
The beach belonging to the Hythe Corporation.
Rye Harbour.
Haddocks (occasionally).
The eastern side of Ecclesbourne Station (hard stone).
Hastings, St. Leonards (at the western end), and formerly from Bexhill.
In large quantities from Langney (Pevensey Bay).
Portobello (between Newhaven and Rottingdean).
Shoreham.
Sand in great quantities from Worthing.

West Sussex, Hampshire, the Isle of Wight, and East Dorset.

The next section of coast to be considered is comprised in *Sheet* 23 of the 4 miles = 1 inch map (as far west as *Portland Sound and including the Isle of Wight*). Of this the eastern part from Goring to Chichester Harbour shows an almost uniform loss, the coast to the south-west of Pagham being the only part which is reported as stationary.

From East Preston (near Littlehampton) a loss of 12 feet took place in the ten years ending at July 1899. The groynes retain the travelling sand and shingle to a great extent, but beach material, chiefly sand, is removed for industrial purposes.

At the eastern end of the sea front at Littlehampton and at Elener Point severe gales have caused an encroachment, but groynes stop the eastward movement of shingle, and the removal of sand tends to prevent the blocking up of the harbour-mouth.

At Felpham the groynes, which when in proper repair retain the shingle, are now (1899) practically useless through neglect, and a loss of 40 feet is reported in the preceding two years, a road and pathway having been washed away. The sea-wall and esplanade are being lengthened by the Bognor Urban Council.

The eastern side of Selsey Bill loses ground, and groynes have been erected to prevent this. Only small quantities of gravel are removed.

Loss also takes place on the western side of Selsey Bill for some 2¾ miles from Corham's Gap to Thorney Barn, the damage being done by heavy south-westerly winds in conjunction with spring tides. Groynes

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have been built to aid the accumulation of sand and shingle, of which but little is removed.

From East Wittering, Bracklesham Bay, an average of 20 feet has been washed away for a distance of 2 miles within two years, due, it is supposed, to the absence of groynes or other protection to the coast. Beach material is not removed.

No groynes have been built on the eastern side of Chichester Harbour, and a loss of land is reported, as a result of high tides and winds which by undermining the cliffs cause small falls, while the neck of shingle at the entrance to the harbour is being gradually driven inwards by the sea in bad weather. No beach material is removed.

The coast from *Chichester Harbour up Southampton Water as far as Woolston* is described in eleven reports. The southern side of Hayling Island is liable to inundation when strong south winds occur with high tides; but, with this reservation, no change is recorded, except a landslip ¾ mile west of Lee-on-Solent (Stubbington), where, owing to heavy rains and strong winds, a mass of cliff 100 yards long and 4 to 5 feet deep fell. The coast on the whole is well guarded. A sea-wall has been built at Eastney (small quantities of shingle are occasionally taken by the Admiralty Works Department), and groynes at Southsea, which prevent loss of beach material, none of which is removed. The neighbourhood of Stokes Bay and to the east (Clay Hall C.G.S.) is also well protected. Forts Blackburn and Haslar are provided with ten wooden groynes which accumulate shingle for the protection of the sea-wall and fort, and three others at Gilkicker Point cause the shingle to gather and form a projecting spit.

Two low groynes built between Stokes Bay Railway Pier and Lee Point have no effect.

It is worthy of note that the southern part of Hayling Island is unprotected, and that the shingle and sand of the beach are removed for industrial purposes.

On Southampton Water rough wooden groynes protect Titchfield Haven, and the groynes have been built near Warsash C.G.S.; but little shingle is removed, though mud is taken from the Hamble River for cement making.

Ten observations from the northern, eleven from the southern coast complete the circuit of the *Isle of Wight*. Five records on the mainland side and no fewer than nine on the southern are of encroachment. From no locality is a gain of land reported. Taking the northern shore first, we may note that no appreciable erosion is taking place along the coast from Nettlestone Point to West Cowes. Between the former locality and Bembridge Harbour groynes have been erected in places, and both sand and gravel are removed. Groynes have been built to the eastward but not to the westward of Ryde Pier, and these collect shingle and sand (the latter is not removed from close in shore). The Binstead and Wootton district is low and muddy with a shingle beach, there are a few groynes on the Osborne estate, and a sea-wall at East Cowes but no groynes. From Colwell Bay to the Beacon at the Needles the coast is stated to neither gain nor lose material. There are five groynes in Colwell Bay. Along the remainder of the shore losses occur: at Bembridge, in places unprotected by groynes which have been only built locally; near Burnt Wood Copse, Gurnard C.G.S., where heavy rains cause landslips, and groynes, moreover, are absent; between

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Hamstead Wood and Saltmead, where the sea has encroached 18 feet in five years, and groynes again have not been erected; and in the neighbourhood of Yarmouth. Here the cliffs for three miles east of Yarmouth Pier are continually sliding on to the beach carrying away small trees &c. in their progress. To the west of Yarmouth Harbour a roadway along the beach has been completely washed away during the five years preceding 1899. From about 1894 to 1903 the annual loss of cliff has been three feet along the stretch of coast from the west end of Yarmouth Common to Hampstead Point. The coast-defences are not unimportant. They consist of a sea-wall 700 yards west and 300 yards east of Fort Albert and another 100 yards long in front of Fort Victoria, and also short groynes along the shore east of Yarmouth Pier. The latter are said, however, to have very little effect on the travelling sand &c. No beach material can be removed without the permission of the Board of Trade, and then only for use in sea-walls &c.

The stationary parts of the southern coast are at the eastern end. From a point half way between Shanklin and Sandown to the Foreland no change is reported. Groynes at the eastern part of Sandown retain the sand, and a small breakwater near the Foreland C.G.S. collects the shingle. Neither sand nor shingle is removed. Returning westward, we find at Freshwater Bay an annual loss of about a foot for a distance of about 300 feet where the cliff is soft. Near Brook (Compton Bay and south-eastward) a report states (probably in 1899) that rocks which thirty years ago formed part of the foot of the cliff are now 58 feet away.

Along the coast 3 miles north-west of St. Catherine's Lighthouse the encroachment of the sea is said to be owing to the bed of the cliff being of blue clay, which, being easily eroded by every gale, facilitates slipping in the overlying mass. There are no groynes, and nothing is removed. The eastern arm of Woody Bay, Ventnor, is disappearing by landslips and exposure to east winds much more rapidly than the western arm, where there is little alteration. At Bennel (June 1899) subsidence of the land is taking place, making a gradual but very rugged slope seaward (by reason of the cracks). A somewhat similar report deals with the coast from Orchard Bay (Ventnor) to Dunnose Point, where encroachment takes place on positions exposed to the S.E., S., S.S.W., and N.S.W. winds. The few groynes along this station collect shingle with W. and S.W. winds, such shingle being removed by easterly winds. Nothing is taken away for any purpose. The lack of sufficient groynes has been given as the cause of the slight loss of land from Dunnose Point to beyond Shanklin Pier. Those already built assist in accumulating the beach, of which none is removed.

No reports have been submitted from the northern side of the Solent or Christchurch Bay, but between *Christchurch Head and Boscombe Chine* an average loss of 3 feet per annum is recorded, with no groynes and nothing removed. Erosion is taking place along the soft cliffs extending from Bournemouth to Poole Head, consisting of the Bagshot beds and plateau gravel, with an admixture of clay. The sandhills stretching from Poole Head to North Haven Point, at the entrance to Poole Harbour, were subject to erosion as far back as records exist; but some years ago they were protected by the construction of a sea-wall near high-water mark, of which a portion, for a length of about 1,940 feet from Poole Head, is perfectly sound; another portion further on is seriously damaged in places, and of the part nearer North Haven Point only traces exist. In

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1896–98, however, thirteen groynes were erected along the foreshore between Poole Head and North Haven Point, which have led to an accumulation of sand along their western sides, and produced an advance of the foreshore.[1] A comparison of the Admiralty charts of 1849 and 1878 shows that a considerable amount of accretion took place along the northern foreshore of Studland Bay within this period, which may be attributed to the protection afforded, during the latter part of this period, by a training bank, carried out in a southerly direction from the southern extremity of South Haven Point, for a length of 1,300 feet between 1860 and 1876; but the latest charts indicate that some accretion has taken place since 1878 in the vicinity of South Haven Point. A small quantity of shingle is occasionally taken from Ballard Point. From this promontory as far as Swyre Head, West Lulworth, practically no loss seems to occur, and no groynes have been built. From West Lulworth as far as the Chesil Beach losses to the coast are common. High spring tides and strong winds, heavy rains, and thaws after severe frosts, are responsible for the damage done. Four groynes formerly erected along the shore at Preston are now reduced to one, which is useless for stopping the travelling beach. A proposal to erect groynes was under consideration in 1899 by the town authorities of Weymouth. No beach material is removed from this neighbourhood except the northern part of Portland.

Three reports include the whole of the Isle of Portland, and mention no alteration. This does not agree with the result of Wheeler's investigations. He notes a loss of land on the eastern side and gives an estimate of loss for 'the centre part of the island' of a foot per annum ('The Sea Coast,' p. 153). When we reach Burton Bradstock, at the western extremity of the Chesil Bank, loss of land is reported. Between Swyre Gulley and Freshwater (Burton Bradstock) there was formerly sufficient land under the cliffs to pasture cattle. This is now gone, replaced by sand and shingle, while the sea beats against the cliff at spring tides. There are no groynes until we reach the eastward side of the harbour at Lyme Regis, and, though but little beach material is removed, encroachments occur as far as 2 miles beyond the county boundary. The loss of cliff in the neighbourhood of Lyme Regis is due almost entirely to the alternation of hard and soft material aided by the percolation of rain. The blue Lias stone is taken away to be burnt for lime.

This part of the Dorset coast has been the subject of several reports on Form II. Two come from the Preston C.G.S. (near Weymouth), recording falls of cliff from the eastern end of the station, in the one case 600 feet long, with a width of 18 to 40 feet, in the other 100 feet long by 50 to 90 feet broad (April 15, 1901). In January 1903 several tons of cliff fell into the sea half a mile west of the Burton C.G.S.; in June 1899 a fall took place between West Bay and Eype; and in September 1902 at Clay Knapp (200 yards east of Eype's Mouth, near Bridport), another 26 yards long by 6 or 8 feet wide.

From near the Devon county-boundary as far as Cliff Castle, Beer Head, there is no loss of coast, and no groynes have been built; but a slight encroachment is recorded from Branscombe.

[1] Report on Poole Harbour Protection to the Poole Harbour Commissioners, by L. F. Vernon-Harcourt, November 24, 1903 (Poole 1903).

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Devon.

Of the *Devonshire coast between Sidmouth and Teignmouth* no records have been received, but between *Babbacombe and Torcross, in Start Bay*, eight observations are to hand. No alterations are reported, except that the inner harbour of Torquay, modified by piers, is gradually filling up, and that in the neighbourhood of Paignton the sea encroaches at the eastern end of Goodrington Sands and on Preston Sands. At the latter place a sea-wall is being built. Elsewhere groynes, &c., are absent, but shingle is removed from the neighbourhood of Babbacombe and from Hallsands, Torcross. Erosion was formerly seriously imperilling the existence of the beach used by fishing-boats in Babbacombe Bay; but a fishing pier erected at the eastern extremity of the Bay in 1889–90, and carried out in a northerly direction for 120 feet as a protection for the fishing-boats, has also caused shingle to accumulate along the shore of the bay within its shelter.

The Start district itself is unequally affected. On the eastern side of the estuary of the Avon loss is recorded from Start Point to within a short distance of East Portlemouth, although the encroachment is but slight. In the estuary of the Salcombe River no change has occurred during the last forty years (up to the summer of 1899), nor is there alteration as far as West Cliff, midway between Bolt Head and Bolt Tail. Losses, however, occur westward from this locality as far as Freshwater Cliffs (about $1\frac{1}{2}$ mile west of Ringmore). Sand and shingle are removed from the neighbourhood of Hope Cove [? Thurlestone Sands].

Cornwall.

From this point *westward along the coast, round Land's End, and along the northern cliffs of Cornwall as far as Bude* (after which the records are fewer) is a stable region of comparatively small changes. These are as follows:—

At Downderry, in Whitesand Bay, the unprotected coast loses about 6 inches per annum. No sand is removed.

To the west of Looe there is a slow encroachment on a low clay cliff—partly protected, however, by a stone wall.

In the neighbourhood of Porthscatho there is also a slight loss; at Polcarnick and Pendower roads have been destroyed. The coast is unprotected, and sand is removed for building purposes.

Near St. Mawes, from Killigerran Head to St. Just Creek, 3 feet of cliff has been lost in seventy years, owing apparently to clay soil giving way. There are no groynes.

At the Lizard between Lean Water and Soapy Cove a slight loss occurs, 'where the cliffs are composed of mica schist.'

Movement of the shingle, in accordance with prevalent winds, occurs to the north-west of Mullion, between Porthleven and Gunwalloe, a succession of south-easterly gales bringing it towards Porthleven to the extent of 10 to 15 feet in depth, whereas south-westerly gales remove it, though not to the same extent, towards Gunwalloe.

From this locality round Mount's Bay itself losses are rather more frequent—as, for instance, in Prussia Cove, especially at spring tides and with a heavy sea, where the cliff is composed of clay and sand. Locally the latter is removed. Erosion also occurs on the eastern side of Mount's

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Bay at Marazion. No change takes place at Penzance, although there are no groynes, and thousands of tons of sand are removed annually for agricultural purposes; but at Newlyn, to the eastward of the harbour, the sea has encroached slightly during the past ten or twelve years, causing the old road along the sea-front to be abandoned. Now, indeed, this road has almost disappeared. To the westward of Newlyn Harbour an artificial beach is being formed by the refuse from quarries.

In the neighbourhood of the Land's End and St. Ives Bay two changes only are on record, both being local falls of cliff arising from heavy gales. The first of these is at Sennen Cove, Land's End, where, however, the loss is very slight, and occurs especially along the back of the beach, which is composed of sandy material; the second is from the Hayle River westward, the cliffs falling away after heavy north-westerly gales. There are no groynes, and no beach material is removed.

Five reports have been received from the *Scilly Isles*. The islands of St. Martin's, St. Mary's, and St. Agnes, situated on the eastern and southern sides of the group, all suffer erosion either where the shore is of a soft nature or by the cliffs falling. No groynes have been built on any of the islands. In St. Mary's the loss in certain places—*e.g.* Porcrasa, Old Town, Porthloo, and Pelistry Bays—varies between '10 and 40 yards in the last five to ten years.'

No shingle, sand, or slabs of stone are removed from the shores of St. Mary's or St. Agnes.

The northern coast of Cornwall from Gwithian to Bude suffers neither loss nor gain, with the exception that local falls of cliff take place near Port Isaac (Bounds Cliff and Kelland Head).

North Devon and Somerset.

The northern coast of Devon and the coast of Somerset are the subject of scattered reports,[1] which will be taken in order.

In the neighbourhood of Clovelly and Hartland Point the cliffs are continually falling. There are no groynes, nor is anything removed.

From Abbotsham Sand Path to Bideford (Barnstaple Bay) no changes are noticeable. There are no groynes, and at Graysand Point, near Barnstaple Bar, sand is removed at low tide in large quantities. From Baggy Point to Lee Bay (Morthoe C.G.S.) the coast-line is stationary; a little shingle and sand is taken from the beach at Woolacombe.

No change is reported from the Ilfracombe district; there are no groynes, but beach material is removed for building and road-metal.

The same applies to the Combmartin district (Watermouth to Heddonsmouth, about twelve miles), and also to the neighbourhood of Lynmouth for about six miles on either hand. A loss of several feet of cliff within three years is, however, recorded from the Minehead C.G.S., between Minehead Pier and Warren Point. Some beach material is removed by private owners. A report from Watchet C.G.S. concerning the shore as far as East Quantock Head mentions that small landslips are of frequent occurrence on either side of the harbour. Shingle is removed from Doniford and sand from wherever it can be obtained.

Letters addressed to Weston-super-Mare and Avonmouth have been left unanswered, presumably because no coastguards are stationed along that part of the Bristol Channel.

[1] Dated July 1903, with the exception of that from Minehead.

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Wales.

The reports sent in are almost entirely confined to *the southern half* of the Principality. Out of twenty-four, eight record loss of land.

At Barry, owing to occasional landslips due to undermining by the sea, this recession of the coast averages a foot per annum. Sand and stones are removed from the beach for building purposes, and pebbles for lime burning. A loss of coast is also taking place at Oxwich, in the Gower Peninsula. Oxwich Marsh is periodically flooded; while in December [? 1898] a landslip detached some thousands of tons of rock. Owing to this encroachment the practice of removing shingle &c. from the shore has been discontinued.

Erosion is also taking place between Llanelly and the Kidwelly River through storms and high spring tides, and is estimated at about 6 feet per annum. Like other parts of Glamorganshire, there are no groynes along the coast. Shingle and sand are removed for industrial purposes.

At Tenby a very slight gain is recorded from Giltar Point to St. Katherine's Rock. Here sand is blown up by the south-westerly wind, and held in position by marram grass. By these means high sandhills are formed, for there are no groynes. Sand and shingle are removed in small quantities, but not sufficiently to make any change in the form of the beach or to cause damage to surrounding property.

In St. Bride's Bay at Broadhaven the sea encroaches slightly, part of the front of the town having been washed away in 1899. Broadhaven is protected by a sea-wall, and shingle and sand have at times been removed from the foreshore.

Stones &c. are taken from the shore at Goodwick, but no changes in the coast-line are given. No groynes are constructed.

At St. Dogmells in Northern Pembrokeshire an encroachment is recorded through gradual rotting of the slate, but at Aberporth the sea is stated to be gaining considerably every year, the blue clay on the foreshore being washed away by the sea. Here also gravel and stones are removed from the beach.

At Penrhyn the cliffs are falling away, the same thing happening at Newquay, Cardigan. At Cibach there are two groynes which catch the shingle, none of which is removed, but with this exception no groynes are recorded from any place in the southern half of Wales.

In regard to the *northern part of Wales* a report has been received from Bangor, including the coast line from Moelfre Island to Great Orme's Head, a distance of 38 miles. This part of the coast is stationary; much is low, with muddy, sandy, or shingle shores, and the vertical range of ordinary spring tides is 19 feet. Sand is used for building purposes. The low sandy coast of Rhyl loses only at the end of the sea-wall, through the backwash of the sea. Groynes built to protect the wall gather sand and shingle.

No coastguard stations are established between Newquay in Cardigan Bay and Carnarvon, along part of the North Welsh coast, and between New Brighton and Maryport. Accordingly information concerning the *Lancashire and Cumberland* coast is but scanty. The marine surveyor to the Mersey Dock Board has kindly given information on the shore between Hilbre Island and Formby Point. He notices an encroachment of the sea along this part of Liverpool Bay. The coast is not protected

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by groynes, but embankments have been put up here and there near high-water mark. Occasionally loads of sand are removed.

At Maryport, in Cumberland, erosion is also reported, especially about half a mile N.E. of Maryport Harbour, where the loss is heavy. The coast is low, and both sand and stones are taken from the shore. At Silloth, where the coast is sandy, and flat, no change is recorded.

Ireland.

From the northern part of the county of *Galway*, i.e. as far south as Galway Bay, six records have been received, some of which mention losses of land. The coast between Slyne Head and Streamstown (Clifden) suffers erosion at Slyne Head itself, at Mannin Bay and at Fahy Bay, and also at Slackpool and Doalaghan. Tully Point (Killary Harbour) becomes almost surrounded by water at high spring tides with northerly winds. Previously under cultivation, it is now a sandy waste through storms.

Mayo provides twelve reports. The first concerns the islands between Westport and Newport Bays (Clew Bay), where the annual loss on those most exposed is from 3 to 5 feet. A certain amount of beach material is removed and coast defences are absent. In the neighbourhood of Achill Sound and Achilbeg high spring tides, with strong winds from the west or south-west, cause a loss of land where the cliffs are low and composed of clay. Nothing is removed, and there are no artificial causes to influence the natural changes.

In Blacksod Bay (and Elly Bay) erosion of the coast is also on record. In 1893 a horse and cart could pass along the cliff outside a boundary-wall which is now lapped by high spring tides, and in one place has been destroyed. From Doohooma a variable state of loss and gain of coast is reported.

On the northern coast of Mayo no alterations are recorded except a gradual washing away of unprotected banks at Ross, Killala Bay, during high spring tides.

No changes are reported from the county of *Sligo*, and in *Donegal* out of eighteen observations three only record alterations.

From Ballyshannon in Donegal Bay observations extending over nearly 41 miles give evidence of both loss and gain. On this stretch of coast there are no artificial protections, and neither shingle nor sand is removed. The other two alterations are on the north-western side of Lough Foyle. On the northern side of Dunagree Point Lighthouse (Greencastle C.G.S.) the sea has encroached about 50 yards during the last forty years (up to 1899), and about half that distance during the same period between Magilligan Point and Downhill in *County Derry*. At Magilligan Point piles have been driven in the shore and have successfully resisted further encroachments. Sand is removed from the bay at Dunagree Point. Near the mouth of the river near the Ark House, Moville, groynes and stone work have been resorted to in order to save the land. This loss appears to be owing to the cartage of gravel and sand from the mouth of the river. In some places, on the other hand, hundreds of acres have been reclaimed by banks, while changes are also made in the channels by the work of steam-dredgers.

In the county of *Antrim* thirteen reports include four of loss, one of which is slight, and one of gain. Along the sandy coast of Portrush land allotted for building purposes was perforce abandoned in 1894. This

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part of the shore is unprotected. The low coast of Portballintrae is undergoing considerable erosion. On the western side of the bay wooden and stone structures have been raised for protection, and these send the sand and shingle eastwards, where much is removed. From Fair Head southwards to Cushendun erosion is slight, while at Cushendall a gain of about 3 feet is on record in the last five years. At a point a mile north of Glenarm considerable loss takes place, the coast-road being gradually set back several feet. One groyne has been erected, but at the time the report was sent in its effect was doubtful. Beach material is removed for industrial purposes, and also at Ballycastle, Larne Harbour, and Whitehead.

In *County Down* the list of losses becomes longer. On the low and rocky coast of Donaghadee an encroachment is noted at a locality about ¾ mile south of the coastguard station ; and between Templepatrick and Ballyferris Point losses have taken place to the extent of 15 feet in the ten years preceding July 1899, and also, according to old inhabitants, between Ballyferris Point and Bray Hill. At Cloghy the house occupied by a former coastguard officer is now (1899) all but washed away. Here one groyne built opposite the coastguard station protects the sea-wall, which lately has been strengthened.

North of the entrance to Strangford Lough (Tara C.G.S.) it appears that considerable loss of land has resulted from the encroachments of the sea, and that the public road is locally submerged during south-easterly and easterly gales. A sea-wall has been built to protect the coast, but gravel and sand are removed for industrial purposes.

In the more southerly part of the county, in the neighbourhood of Dundrum Bay and Kilkeel, losses are practically continuous for a considerable stretch of coast. From ' Big Pack,' Ballykinler, past the coast-guard stations of Newcastle, Annalong, and Kilkeel the sea is reported as encroaching at several points. These are : from Murlough Point to Long Hill, south of the Dundrum River ; between the bar of Dundrum and the Shimna River ; between the Ballagh River and Black Rock, Annalong, and at the harbour of Kilkeel, with the adjacent localities of Leeston's Point and Ballykid. Beach material is removed from many places along the coast and in great quantities from the neighbourhood of the Dundrum River. High tides and strong southerly or south-easterly gales are given as the reasons for many of the losses. Coast protections have been erected in several places. A sea wall has been constructed from Newcastle Harbour for about half a mile northwards and the beach paved with boulders, while groynes, which appear to act successfully, have been erected under the esplanade and New Railway Hotel. Three groynes have been erected at Kilkeel Harbour.

Passing southwards we find a loss of land occurring at Cranfield Point, where the sea has washed away the pillars of the gate of the lightkeeper's house. The Commissioners of Irish Light have now had the cliff faced with stone and cement. At Greenore, near the southern entrance to Carlingford Lough (*County Louth*), slight encroachment is noted.

On the northern side of Dundalk Bay, near Giles Quay, the sea is encroaching along a strip of coast about 1¾ mile in length, a loss of 45 feet having occurred in places during the last six years. A groyne at the back of the fishing pier tends to accumulate the sand and shingle, which is, however, removed for making concrete. A report covering nearly

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9 miles of coast around Soldier's Point, Dundalk Bay, mentions no change; but from Dunany Point, the southern extremity, a considerable loss results from gales washing away portions of cultivated land to the N.N.W. of the coastguard station. The southern part of a sea-wall built on the Dunany estate is now nearly destroyed, although it is only reached by the tide in bad weather. Gravel is removed as ballast.

The coast is stationary near Clogher Head and the mouth of the Boyne; neither station is protected. Beach material is removed from the latter.

The ample reports from the *County of Dublin* provide a heavy record of loss, greater on the whole from the northern part of the county. Amongst these is included a report from Laytown, in the *County of Meath*. It is interesting at the outset to notice that groynes are absent almost throughout the former county.

Within 500 yards of the Nanny River (Laytown), on either side, the sea has encroached 30 feet during the last twenty years, while losses are recorded near Balbriggan; from the east end of South Strand to Skennick Point near Skerries; near Rush, when heavy gales from the east or south-east occur at spring tides; and near Rogerstown and Portrane. On the other hand, the coast around Lough Shinny, Malahide, and Baldoyle is apparently undergoing no change.

Shingle, sand, slabs of stone, and other material are removed from the beach at Balbriggan, from the northern end of South Strand at Skerries, to a minor degree from Rush and Portrane and Lough Shinny. A report from Lambay Island states the coast is without alteration; that no shore-defences have been erected, and that shingle is used only for the pathway to the coastguard station.

The headland at Howth and the northern side of Dublin Bay show neither loss nor gain. In the centre of Dublin Bay, however, from Poolbeg Lighthouse to Booterstown, inroads of the sea may accompany south-easterly gales. No changes are reported from Kingsdown and Dalkey, but a rapid erosion is taking place between Killiney Bay on the north and past Bray Head to Six Mile Point. The Dublin, Wicklow, and Wexford Railway Company has built a sea wall at the foot of part of the cliffs to the north, but hereabouts two Martello towers have entirely disappeared with the fallen cliffs, while part of the foundations of a third protrudes over the edge (1899). From time to time during the past ten years the railway has removed its permanent way inland, in places 10 to 30 feet, while at the date the report was written the rails in places are only a few feet from the edge. No beach material is reported as having been anywhere removed, and south of the Cable Rock groynes have been placed to protect the embankment. Southwards as far as Cahore Point the loss of land is much less severe. Near Five Mile Point the coast-line is stationary, no artificial restrictions stay erosion, and gravel &c. is removed for paths and the like. Near Wicklow, however, the sea encroached for the last fifty years at an average rate of 3 feet per annum, while from the Old Strand House to Steam Packet Pier gravel accumulated by being washed down from the northern part of the beach. Groynes have not been built, and from one place beach material is removed. Between here and Cahore Point loss is recorded only along the stretch of coast 7½ miles southwards from Arklow Head, past Kilmichael Point. The coast is low, with sandbanks, and it is these which are being washed away by the sea. The beach, which is of a mixed character, is removed for industrial purposes.

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Near Bar of Lough, between Bentley Cottage and Ballinadressoge (Curracloe), and between Rosslare Fort, in Wexford Bay, and Ballygeary, loss of land by gales and landslips is frequent. The battery wall of the R.N.R. drill ground (Rosslare) is now 12 yards 'seaward of the land,' a result produced in thirty years. Northerly and north-easterly gales and heavy rains are active agents of destruction. Near the railway pier (Ballygeary C.G.S.) small quantities of gravel are removed for filling in the sleepers. This coast is either low and sandy or formed by 'marl cliffs' averaging some 60 feet in height.

Round Carnsore Point, as far west as Takumshin, the cliffs are composed locally of a 'yellow clay,' and in these places the coast loses considerably. No artificial causes stay encroachment, and small quantities of shingle and sand are removed.

Between Takumshin Bar and Kilmore C.G.S. high tides and gales of wind break away the low sand and clay cliff to an extent estimated during the last fifty years at between 2 and 3 yards per annum. The older inhabitants of the district remember houses standing on sites now covered by the sea. For about 500 yards east of Kilmore the harbour works retard the waste of cliff during the prevailing winds. To the eastward farmers remove the sand in small quantities.

At Morris Castle about 28 yards of land have been washed away since 1862. The cliffs, about 50 feet in height, are composed of sands and marls, and the sand and shingle of the beach is removed.

From the eastern side of Bannow Bay, as far as and along the eastern side of Waterford Harbour, the coast loses ground locally. From Fethard C.G.S. losses are reported at Wood, between Baginbun and Carnivan, and also between Loftus Hall and Harry Lock; and from Arthurstown C.G.S. landslips occur in the vicinity of Booley Bay.

No alterations are taking place between the western side of Waterford Harbour and Mine Head, south of Dungarvan Harbour, except at Tramore, where the sea encroaches on the strand to the south-east of the station through unusually high tides and winter gales. Unfortunately a large amount of shingle is taken away.

The Waterford coast south-west of Mine Head, *i.e.* in Ardmore, Youghal, and Ballycottin Bays, is undergoing erosion. A few groynes have been placed to break the force of the waves against the sea-wall at Ardmore village, but otherwise Ardmore and Whiting Bays are unprotected, and a considerable amount of sand is removed. At 'Claycastle' and a mile to the westward (west of Ferry Point, Youghal) the sea in February 1899 made a breach about 50 yards wide in the foreshore, and the loss on Garryvoe Strand (Ballycottin Bay) is said to be a third of a mile in forty years. Reports stating loss of land come from the coastguard stations at Knockadown, East Ferry, Ballycrenane, and Poor [? Power] Head. Groynes have been built to the west of Youghal, but along the remainder of the coast line defences are absent. The nature of the shore varies greatly: it is formed by precipitous cliffs near Knockadown, but of lower cliffs of variable height and texture to the westward, rising again at Poor Head. Near the latter C.G.S. and that of Ballycrenane beach material is removed in small quantities, as well as from Ardmore and Youghal.

Neither side of Cork Harbour is apparently suffering erosion, nor is the coast as far westward as Ringabella Bay, but at Robert's Cove and Rocky Bay the losses within the last five years have been respectively

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20 and 25 feet. A sea-wall has been partially destroyed, but there are no groynes, and sand is removed from Robert's Cove at low water.

The neighbourhood of Reanies Bay and Kinsale Harbour is stationary, but between Hake Head and the Old Head of Kinsale low sandy cliffs have been levelled and covered by the beach within the last five years. The coast from Courtmacsherry Bay westwards to Clonakilty Bay is undergoing continual and obvious erosion where unprotected by rocky cliffs. At the eastern end of Broadstrand in Courtmacsherry Bay the sea flows over a spot where thirty-five years ago houses were to be seen; an advance estimated at about 30 yards. One mile westward at Blindstrand a road formerly crossed from Lislee village to Coolbawn, on the opposite side of the strand. This is now 130 yards outside the present high-water mark, and it is estimated that during the last thirty years 16 acres of land have been lost. Coast-defences have not been neglected: the Board of Public Works built a wall 200 yards in length on the eastern side of Blindstrand to save the village of Lislee, and the local railway company another on the river Argidean to protect their property.

The remainder of Clonakilty Bay and the coast westward past Cape Clear as far as Mizen Head is a stable region of bold rocky cliffs broken now and again by sandy beaches and coves. The coast is unprotected, but little material is removed, and no alteration is on record except a slight gain of land around Schull, where the spring tides do not run so far up into the land as once they did.

The rugged and indented coast of Bantry Bay and the Kenmare River is without observations, but from Ballinskelligs Bay northward the records are fairly complete.

Between the last-named inlet and Brandon Head the changes are but few. The waves at the north-eastern end of Ballinskelligs Bay have to some extent worn away the cliff at exceptionally high spring tides. There are no groynes, and the taking of sand from the beach appears to produce no appreciable effect.

In front of Ballinskelligs C.G.S., on the western side of the bay, a loss of 2½ feet is recorded in the four years preceding 1899. A pier close by is suggested as being the cause of this erosion by collecting shingle on one side and producing thereby an eddy which does the damage. No shingle is removed.

On the southern side of Dingle Bay, between Coonanna Point and Rossbehy Point, the sea encroaches, especially in the winter with southerly or south-westerly gales. The cliffs under the Bathing Cottages at Rossbehy were protected by large blocks of concrete, joined with railway-irons and balks of timber. These having no effect, large concrete blocks were sunk in the sand and boards placed from one to the other; but at the date of the report (August 1899) the time had been insufficient to test the effect of this arrangement.

Losses occur in both Dingle and Smerwick Harbours. In the former a sea-wall formerly existing on the north-eastern side has now been washed away, and also a portion of the adjoining land, while abreast of the town and public road walls have been built to prevent encroachment.

In Smerwick Harbour for a stretch of a mile (viz. from Ballynagall Point to Murriegh) a cliff of average height of some 12 feet is crumbling through the action of the sea, which has broken into an old public road and rendered it almost impassable. The fishing-pier at Ballynagall has probably retarded the erosion of the banks in its vicinity.

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Local loss of land is reported from the C.G.S. at the mouth of the Casheen River, and north of the mouth of the Shannon along the stretch of coast between Kilkee and Milltown Malbay.

The annual loss from Goolen to Doonbeg Bridge (Kilkee) is given as 6 inches, an estimate derived from information given by the older fishermen, while northwards it is rather greater, in Mal Bay, where the cliffs are less high than to the south and interspersed with low and sandy coast. Some sand is removed and no groynes have been built. The northern shore of Galway Bay and the Aran Islands show no change (small quantities of sand are removed), but the southern shore from Kilcolgan Bridge northward for 30 miles is undergoing gradual erosion.

The vertical range of ordinary spring tides may be summarised by taking the averages of a number of observations at adjacent points. The figures (in feet) are as follows :—In the Solway Firth 22·5, falling off to 15 in Wigtown and to 9 off the Ayrshire coast and towards the Firth of Clyde. On the Caithness, Sutherland, coast the readings are 15, decreasing to 13 in the Moray Firth, to rise to 16 off Peterhead and Aberdeen. A lowering of about 2 feet takes place towards the Firth of Tay to rise again to the same level (16) off the Haddington coast, whence there is a gradual decrease of about 3 feet to Hartlepool. At the mouth of the Humber, however, the range is 19 feet (21·75 at Barton) ; but while maintaining an 18 or 20 feet range at the entrance to the Wash the variation is much lower off the East Anglian coast (say 7·5), thence gradually increasing to 18·75 round East Kent. The highest reading on the southern coast is in the neighbourhood of Hastings (24) ; the lowest on the southern side of the Isle of Wight, and towards Portland (7·5 and 9·8 respectively). Once more the range rises to about 16, which is maintained to the North Cornwall coast, where the figures again increase (18·75) to 27·5 in North Devon. On the Glamorganshire coast we find 33·8, in the southern part of Cardigan Bay 12, on the North Welsh coast 19, and in Liverpool Bay 27·5. The variations in Ireland are less conspicuous, in Galway Bay 12·5, decreasing slightly as we go northwards, and being decidedly less between Malin Head and Belfast Lough (8·7 to 7·4). Southwards the range increases to 14·6 off County Down, 11·8 off County Dublin, and varies between 13·25 and 11·75 off the southern coast.

In this report little or no description is given of the nature of the coast. Mr. Wheeler's book supplies this defect for England, while, in judging from the reports sent in, it is often doubtful how closely a general description of the coast can be applied to any particular part which is undergoing change. The writer concluded that details of this kind would not add materially to the value of the report and would greatly increase its length.

[Since this Report was read at the Southport Meeting, Mr. R. G. Allanson-Winn has published various criticisms in letters to the *Times*, *Daily Express*, and other publications, and has sent numerous communications on the subject to the Committee. It has been thought best, however, to allow the Report to be published as it stands, and any corrections which may be found necessary, either in the information supplied by the Coastguard Service or in the deductions drawn from it, can be inserted in the next Report submitted to the Association.]

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Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Professor G. B. Howes (*Chairman*), Mr. J. E. S. Moore (*Secretary*), Dr. E. Ray Lankester, Professor W. F. R. Weldon, Professor S. J. Hickson, Mr. A. Sedgwick, *and* Professor W. C. McIntosh.

Report on the Occupation of the Table during February, March, April, and half of May, 1903.

The Oocyte of Tomopteris. By William Wallace, *B.Sc.*

At Naples I studied the earlier stages of the oogenesis of *Tomopteris onisciformis*, Esch., and particularly the changes in the germinal vesicle during the growth of the oocyte.

Since Eschscholtz discovered this species in 1825, several naturalists, including Claparède, Vejdowski, Carpenter, and Fullarton [1] (1895), have dealt with the genital products of Tomopteris, and have described the more obvious features of the oogenesis, such as the following :—

1. The origin of the ovaries in the rami of the parapodia by proliferation of cells of the cœlomic epithelium.

2. The detachment from the ovary and discharge into the cœlom of balls of cells. One cell of each cluster, increasing in size, becomes the *oocyte*, while the remainder—some half dozen or so—continue attached to the larger cell, and constitute the 'nurse-cells.'

3. The growth of the oocyte (apparently) at the expense of the group of nurse-cells, which is soon no more than a cap or small appendage at one pole of the egg. These nurse-cells finally degenerate and disappear.

Such phenomena are not diagnostic of the oogenesis of Tomopteris, but have been described for other Polychætes, such as Ophryotrocha (Korschelt [2]), Onuphis (Bergmann [3]), &c.

The cytological changes accompanying the growth and maturation of the egg of Tomopteris do not appear to have been studied hitherto. Some observations on this head may accordingly be of interest.

The material at my disposal was, thanks to the kindness of Dr. Lo Bianco, tolerably abundant. The species, however, does not seem to be so plentiful here as, for example, at St. Andrews, where, during certain seasons, large quantities are found in the tow nets. Neither were the ripe female specimens so large at Naples. All that I had to deal with were under a centimetre in length, whereas at St. Andrews the specimens commonly attained a length of two or three centimetres (if I remember rightly).

In all the Neapolitan specimens I examined numerous gregarines occurred, mostly in an encysted condition in the epithelium of the gut.

I studied the eggs in the fresh state, when, like the whole body of Tomopteris, they are transparent. I also studied them in serial sections of fixed material.

[1] Fullarton, *Zool. Jahrb.* (*Spengel's*), Morph. Abth., viii. Bd., 1895.
[2] Korschelt, *Zeit. für wiss. Zool.*, Bd. lx. 1895.
[3] Bergmann, *Zeit. für wiss. Zool.*, Bd. lxxiii., Hft. 2, 1902.

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The following points were made out in the larger eggs before treatment with reagents.

The eggs are perfectly spherical and transparent. The nurse-cells, if still present, occupy a small area at one pole. There is no follicle around the egg, but an extremely fine membrane (? zona)—which therefore, as Bergmann points out for Onuphis, must be an independent product of the egg itself—is present at the surface. In the cytoplasm just under the membrane minute highly refracting droplets, probably of oil, can be discerned. They are often in clusters and of various sizes. In the very centre of the egg is the perfectly spherical germinal vesicle with a single highly refractive germinal spot or nucleolus. Occasionally one or two smaller refractive bodies (the 'neben-nucleoli') may be seen within the germinal vesicle. The position of the germinal spot is invariably eccentric. Vacuoles varying in number and size could be distinguished in the nucleolus, except in the case of the largest eggs. The nucleolus of the full-sized eggs was notably smaller and at times contained a small vacuole. The nucleolus, therefore, enlarges up to a certain point in the growth of the oocyte and then diminishes. Its complete dissolution was not observed.

The space between the germinal vesicle and the egg membrane is filled up with yolk spheres. These are nearly uniform in size, and almost touch one another, leaving very little protoplasm between. The spheres are not very highly refractive, and are therefore only vaguely discernible in the fresh egg.

In the germinal vesicle of the full-sized eggs one can distinguish, besides the nucleolus, certain nebulous or flocculent masses. These are the definitive chromosomes. To see them in the fresh egg requires a certain intensity of light and careful focussing.

By the addition, under the cover-glass, of an aqueous solution of methyl green more facts were brought to light. As the green solution reaches the eggs these swell up somewhat and burst their membranes. Often the yolk is extruded in small drops through the substance of the membrane, the external surface of which is accordingly studded with drops. This observation seems to indicate that the egg membrane of Tomopteris, like the zona radiata of vertebrates, is perforate. The protoplasm flows out through a rupture in the capsule slowly, sometimes in long strings like a syrup. The yolk spheres entangled in it generally adapt themselves to the size of the aperture and pass out intact. On coming in contact with the watery solution they break down and flow together. The yolk spheres are, I think, evidently viscid drops of some albuminous substance. Inside the egg the syrupy protoplasm in which the spheres are imbedded appears quite homogeneous and translucent, but as it flows out into the watery methyl-green solution minute granules (? microsomes) come into view in its interior. It is probable that, as Wilson[1] has observed in the case of certain Echinoderm and Annelid eggs, the yolk of the Tomopteris egg forms a true emulsion in Bütschli's sense. I cannot, however, definitely state the existence of microsomes in the cytoplasm of uninjured eggs, *i.e.* before contact with the methyl-green solution. Probably they are naturally present in this transparent egg and only require a coloured solution, like methyl green, to show them up.

[1] Wilson, *Journal of Morphology*, vol. xv., Supplement, 1899.

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Turning now to the germinal vesicle, after treatment with methyl green. This body is often extruded intact. As the green solution reaches it, minute refringent granules in constant dancing motion come into view. After oscillating for some time these granules settle down and arrange themselves in a network formation. Here again, as in the case of the microsomes, it is not very easy to say whether the granules pre-existed in the natural state of the egg. In the meshes of the network larger granules (? lanthanin of Heidenhain) were seen. None of these minute granules stained with the methyl green; in fact, the only structures in the nucleus which take up this stain are the chromosomes (strong) and the nucleolus (faintly). The chromosomes appear to be rings or loops of irregular form. They are very thick and roughly moniliform—very different in appearance from the smooth outlined attenuate loops depicted by Korschelt in the nearly ripe egg of Ophryotrocha. I counted four chromosomes in full-sized eggs of Tomopteris. Korschelt gives the same number for Ophryotrocha.

The numerous unstainable granules in the full-grown germinal vesicle of Tomopteris appear to correspond to Heidenhain's[1] *oxychromatin granules*, while the substance of the chromosomes—which stains with methyl green—is *basichromatin*.

Besides the larger eggs, oocytes with chromatin in the primitive spireme stage were examined after treatment with methyl green. The spireme stains intensely. In somewhat older oocytes with reticular nucleus the nucleolus lies eccentrically in the nucleus, and is surrounded by a vacuole to the walls of which it is moored by radiating threads of the network. The growth of the nucleolus keeps pace with the growth of the germinal vesicle and of the oocyte. It is at first homogeneous, but becomes gradually more and more vacuolated. These small vacuoles fuse to form a single large eccentric vacuole. Finally, in full-sized eggs, the nucleolus is smaller, and contains no large vacuole. It seems probable therefore that the decrease in size is due to the collapse of the vacuole and discharge of its fluid contents into the nucleus.

For sections various methods were tried. The fixing agents employed were chiefly Mann's picro-corrosive-formol mixture, Gilson's mercuro-nitric-acetic fluid, Hermann's fluid, and Boveri's picro-acetic. The Hermann preparations were stained with thionin or safranin. The others were variously treated, the chief combinations employed being Heidenhain's iron-hæmatoxylin with orange green, Delafield's hæmatoxylin with eosin or congo-red, borax carmine and picro-nigrosin, and nigrosin and 'light green.' On the whole, perhaps the best results were obtained with material fixed in Boveri's picro-acetic and stained with nigrosin and light green. The latter is a very rapid staining method, and gives a good chromatin-achromatin differentiation. It suffices to stain for one and a half minute in a saturated aqueous solution of nigrosin, and then for half a minute in an alcoholic solution of 'light green.' By this method only the chromatin proper stains black, while the nucleolus and the cytoplasm stain green. The nucleolus is especially prominent in these preparations, appearing as a shining green body. The nucleoli both of the germinal vesicle and tissue cells, such as the epithelium of the gut, stain similarly with the light green, and do not take up the black. Nigrosin, however, does not distinguish between oxychromatin and

[1] Heidenhain, 'Ueber Kern und Protoplasma,' *Festschr. für Kölliker*, 1892, &c.

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basi-chromatin : both constituents stain black. Its chief use is for differentiating the nucleolus from the chromatin. This is what iron-hæmatoxylin, for example, does not do.

The results of staining sections of the fixed ova of Tomopteris were as follows :—

Iron hæmatoxylin and orange G. varies a good deal, according to the time allowed for extraction of the stain with iron-alum. After a long extraction primitive spireme, nucleolus, and definitive chromosomes, black. Oxychromatin, orange. Cytoplasm, purple. Yolk spheres and zymogen granules of gut cells, pale.

Delafield's hæmatoxylin and eosin.—Nucleolus, brick red. Chromatin, blue to light red, according to age of oocyte.

Borax-carmine and picro-nigrosin.—Nucleolus and definitive chromosomes, bright red. Remaining nuclear contents, purple.

Nigrosin and light green.—Nucleolus, green. Chromatin, black. Cytoplasm, green.

It will thus be seen that with certain combinations of dyes nucleolus and 'basi-chromatin' stain alike, whereas other double stains differentiate these two constituents of the nucleus. The result is rather conflicting.

The precise origin of the nucleolus or germinal spot could not be made out. It is present when the chromatin is in the spireme stage and the nucleus has as yet no definite membrane. When the membrane is formed the nucleolus is applied to its inner surface, and has one side flattened against the latter. As the egg grows the nucleus leaves the wall and lies eccentrically within the nucleus. It is invariably surrounded by a vacuole, to the walls of which it is moored by threads of the nuclear reticulum. The progressive vacuolisation of the germinal spot has been already referred to.

The large eccentric vacuole of the germinal spot owes its origin apparently to the fusion of numerous smaller vacuoles. When this fusion is complete the germinal spot has attained its greatest size. The single large vacuole—in stained sections—contains a reticulum with granules staining exactly like the nuclear reticulum, although no communication between the vacuole and the contents of the nucleus could be certainly demonstrated. This vacuole with its contained reticulum corresponds to what certain authors call the plastin portion of the nucleus and to the 'nebentheil' (Flemming [1]) of the nucleus of the Lamellibranch egg. The reticulum looks exactly like an included portion of the general nuclear reticulum. It may, however, be due to the coagulation of the intravacuolar fluid.

The germinal spot or chief nucleolus of the oocyte of Tomopteris is certainly not a karyosome ; neither is it a chromatin nucleolus in Carnoy's sense ; that is to say, it has no genetic relation to the chromosomes or 'nucleinkörper' as have the numerous nucleoli of the germinal vesicle of Amphibia and Fishes (according to Carnoy [2] and Rohde [3]). Further, there appears to be no difference, as regards staining properties and morphological relations, between the germinal spot of the egg and the nucleolus

[1] Flemming, *Zellsubstanz, Kern und Zelltheilung*, 1882, &c.

[2] Carnoy et Lebrun, 'La vésicule germinative et les polaires globules chez les Batrachiens,' *La Cellule*, 12, 14, 17.

[3] Rohde, 'Ueber den Bau der Zelle, i. Kern und Kernkörper,' *Zeit. für wiss. Zool.*, Bd. lxxiii., Hft. 4, 1903.

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of the tissue cells, such as the gut epithelium. 'Neben-nuclei,' or secondary nuclei of minute size, are to be found in the germinal vesicle during the growth of the egg. They stain like the chief nucleolus, and are often found in close proximity to this body. Similarly staining granules found in the vacuole or vacuoles of the chief nucleolus may be of the same nature. These 'neben-nucleoli' are variable in size and number. They may be readily demonstrated by means of iron-hæmatoxylin or by the nigrosin-light-green combination. In the iron-hæmatoxylin preparations minute black granules resembling the neben-nucleoli were found scattered in the cytoplasm as well as in the germinal vesicle. Roule (Ascidian ova) and others have described a migration of nucleoli into the cytoplasm. Recently (1901) Schockaert [1] (Thysanozoon) and Gérard [2] (Prostheceracus) have noted the presence of such chromatophil bodies in the germinal vesicle and their elimination into the cytoplasm. Both authors employed iron-hæmatoxylin. Gérard considers that these bodies represent portions of waste nuclein derived from the chromatin element and destined to be eliminated from the nucleus. Schockaert, on the contrary, thinks that they are 'nucleolules,' which first appear in the 'plastin portion' of the chief nucleolus, and are afterwards expelled into the nucleus, where they form secondary nucleoli, and there dissolve. According to him, they do not contribute to the formation of the chromosomes. Rohde (1903) describes a chief nucleolus and numerous 'neben-nucleoli' in the egg of the cat. He thinks that the former is a 'cell organ,' and that its vacuoles have a secretory significance (*cf.* Häcker [3]), while the 'neben-nucleoli,' like the ordinary nucleoli of the Amphibian egg, are genetically related to the chromatin granules (nucleinkörper), the two kinds of granules being mutually convertible.

I could find no evidence in the case of Tomopteris for a relation between the neben-nucleoli and the substance of the chromosomes. The circumstantial evidence was rather in favour of Schockaert's view that the neben-nucleoli are derived from the chief nucleolus. I could not decide whether the chromatophil granules in the cytoplasm were of the same nature. They were only seen in the iron-hæmatoxylin preparations and may be artefacts.

There is no evidence that the chief nucleolus gives direct origin to the chromosomes of the first maturation figure, although several observers have stated and figured such a relation in the case of other eggs. The definitive chromosomes are formed apparently quite independently of the chief nucleolus. I have seen nothing resembling Carnoy's and Hartmann's [4] figures of chromatin filaments emanating from nucleoli. The definitive chromosomes are formed while the membrane of the germinal vesicle is still intact. They arise apparently by a condensation of the pre-existing chromatin by a growth and possibly a fusion of certain granules along certain tracts. The granules composing the chromosomes differ in two respects from the granules of the general reticulum :—(1) they are larger, and (2) they stain with methyl green, hæmatoxylin, and other 'basic' dies.

The changes in the chromatin of the nucleus from the primitive

[1] Schockaert, *La Cellule*, 18, 1901.

[2] Gérard, *ibid.*

[3] Häcker, *Das Keimbläschen, seine Elemente und Lageveränderungen*, i. ii.; *Arch. f. mikr. Anat*, Bd. xli. xlii., *Jahrg.* 1893.

[4] Hartmann, 'Eireifung von *Asterias glacialis*,' *Zool. Jahr.* xv. 1902.

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spireme stage up to the formation of the definitive chromosomes will now be briefly described. As the egg grows, the chromatin undergoes a progressive change both in structure and in staining property. In the spireme stage it consists of a thick filament loosely coiled and lying in a vacuole in the cytoplasm. This filament has a square or polygonal cross-section and is monilated. I did not observe any signs of a longitudinal division of this primitive spireme. Threads (? linin) extend in ladder fashion between the monilations on adjacent portions of the filament and similar threads (green with nigrosin-light green) moor the coil to the walls of the vacuole in which it lies. Later a definite nuclear membrane lines the walls of this vacuole, and would thus appear to be of cytoplasmic origin. The chromatin of the spireme has a compact appearance even under a $\frac{1}{12}$ oil-immersion lens.

The chromatin of the spireme stains deep black with iron-hæmatoxylin, and intensely blue with Delafield's hæmatoxylin. During the growth of the oocyte the spireme is gradually resolved into a network in a manner not very clearly understood. The compact substance of the spireme is resolved into distinct granules which are distributed along the threads of a now copious reticulum, but are more massed together at certain points. The germinal vesicle of the more advanced eggs has a beautiful open network with very large meshes. *In this diffuse form the chromatin does not stain readily with hæmatoxylin, but rather with acid dyes*, such as eosin, orange G, and congo red. It possibly corresponds to the oxychromatin of Heidenhain. This progressive change in staining properties on the part of the chromatin during the growth of the egg may, as Rohde (1903) asserts for cells in general, be the expression of a loss of phosphorus on the part of the chromatin granules (*Nucleinkörper*). The observation is quite in line with the chemical researches of Zacharias, Rosen, and others, according to whom the nuclei of the meristomatic cells of plants contain more phosphorus than the nuclei of cells which have been growing for some time.

Again, when the definitive chromosomes are being formed, that part of the chromatin which goes to form these bodies stains intensely with hæmatoxylin, and, in the fresh state, with methyl green. The remainder of the chromatin—the 'residual chromatin' of authors—is acidophil in its reaction.

In connection with the important but difficult question as to which of the manifold appearances in fixed and sectioned cells represent organised structures, and which are mere coagulation products, some observations on the yolk spheres of the egg of Tomopteris may be mentioned.

The yolk spheres, as may be easily demonstrated in the living egg by pressure under the cover-glass, are fluid or viscid drops, and must, of course, be regarded as inert bodies: they are quite homogeneous until attacked by a fixing reagent, such as a drop of Gilson's fluid let under the cover-glass. The yolk spheres then appear—under a low magnification—to have a uniform granular structure. Under a high power ($\frac{1}{12}$ oil immersion) this granular structure resolves itself into a beautiful uniform network, like that of a nucleus in the resting stage, except that the reticulum is quite uniform throughout. There can be little doubt that this reticulum is a pseudo-structure due to the coagulating action of the fixing fluid. In sections the spheres are often to a greater or less extent dissolved, and cease to fill completely the vacuole in the protoplasm which they formerly occupied. This pseudo-reticulum can be easily

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stained with iron-hæmatoxylin if care be taken not to extract too long with the alum. In such preparations the resemblance to a nucleus is very striking.

The cytoplasm of the egg of Tomopteris in stained sections under a high power presents a most distinct reticulum, the granules seen under a lower power being apparently the cross-sections of filaments. This is equally true of the scanty cytoplasm which lies between the yolk spheres in the larger eggs. The difficulty is how to reconcile this observation with the emulsion structure noted in the fresh egg. It may be that the 'microsomes' certainly seen in methyl-green preparations have been dissolved out, and that it is the network of intermediate or 'continuous substance' which is seen stained in sections.

The material available at Naples during my occupancy of the table did not provide me with any stages later than that at which the definitive chromosomes are formed. I was unable, therefore, to study the polar bodies and fertilisation in this form. The preparation of a detailed and illustrated account of my observations, which I hope to extend, and a discussion of the more important literature bearing on the subject must stand over in the meantime.

In conclusion I desire to thank heartily the Committee for the use of their table, and to express the sense of obligation which every student of marine zoology must feel who has had the privilege of working at the renowned Stazione. Of the kind attention of the authorities of that institution I entertain the most pleasant recollections.

Index Generum et Specierum Animalium.—Report of the Committee, consisting of Dr. HENRY WOODWARD (*Chairman*), Dr. F. A. BATHER (*Secretary*), Mr. W. E. HOYLE, Mr. R. MCLACHLAN, Dr. P. L. SCLATER, *and the* Rev. T. R. R. STEBBING.

THE Committee have the honour to report that at the end of October, 1902, the first volume of this work was published. It covers the period 1758–1800, and was issued by the Cambridge University Press. The volume consists of 1,254 pages, viz. 59 pp. of 'Introduction and Bibliography,' 1,071 pp. of 'Index,' and 124 pp. of 'Index to Generic Names, showing the trivial names associated with each,' from 1758–1800.

The work has been well received, and favourable reviews have appeared in the 'Geological Magazine,' 'Revue des Questions Scientifiques,' 'Zoologist,' 'Zoologisches Zentralblatt,' 'Entomologists' Record,' 'Science,' 'Athenæum,' 'Nature,' 'American Journal of Science,' &c.

Numerous letters have also been received from the Continent and America containing gratifying expressions as to its value to zoologists.

The indexing of 1801–1900 continues in a satisfactory manner, but it is of necessity slower, as the question of the determination of dates of publication of works which have appeared in parts makes the compiler's progress a very laborious one.

The amount of last year's grant has been drawn (with the authority of the Committee) and applied by Mr. C. Davies Sherborn to the carrying on of the work during the year now ending.

The Committee earnestly request reappointment with a grant of 100*l*.

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Bird Migration in Great Britain and Ireland.—Sixth and Final Report of the Committee, consisting of Professor NEWTON (*Chairman*), Rev. E. P. KNUBLEY (*Secretary*), Mr. JOHN A. HARVIE-BROWN, Mr. R. M. BARRINGTON, Mr. A. H. EVANS, *and* Dr. H. O. FORBES, *appointed to work out the details of the Observations on the Migration of Birds at Lighthouses and Lightships*, 1880–1887.

IN submitting this, which, according to the intimation more than once previously given, your Committee intend to be their last Report, they again have the pleasure of including a summary by Mr. William Eagle Clarke of the observations on the highly interesting movements of two well known species, the Starling (*Sturnus vulgaris*) and the Rook (*Corvus frugilegus*), which he has prepared with the same skill as he exercised upon the six species he has treated in former Reports, and with, if possible, a greater expenditure of time and toil, on account of the difficulty of coping with the details of such complicated movements as are therein recorded.

Your Committee feel that, while Mr. Clarke's work speaks for itself, they find it hard to express their indebtedness to him for the labour he has undergone in drawing up the eight summaries, a labour almost unrequited, and so great that nothing but intense zeal would render its performance possible. Everyone acquainted with the subject of Bird Migration will admit that, owing to the plan followed by Mr. Clarke, so much information in regard to the species whose movements he has worked out has never been given before, and that within space which cannot be deemed excessive.

It will be observed that of the eight species which have been the chief subjects of attention, only two, or three at most—the Swallow, the Fieldfare, and, perhaps, the White Wagtail—are popularly considered to be 'Migrants' in this country, the others, being, *as species*, resident in it throughout the year. Yet nothing has been more clearly proved than that, *as individuals*, Song-Thrushes, Skylarks, Lapwings, Starlings, and Rooks are migratory in the highest degree, a fact which had before been known to comparatively few ornithologists, and wholly unsuspected by the public at large, though these are among our most familiar birds. The clear way in which this has been set forth by Mr. Clarke ought to remove all misapprehension on this matter, and in itself almost justifies the whole inquiry, instituted more than twenty years ago, since an obvious inference is that many other species must show the same character, and hence that Migration, among birds of these islands at least, instead of being the exceptional quality it was once thought, may be general.

It would no doubt be extremely desirable for more species to be subjected to the same rigid examination as the eight upon which Mr. Clarke has laboured, but your Committee believe that the results would hardly repay the toil. It is not to be expected, of course, that any two species, even among those most nearly allied, would be precisely alike in their movements, but the amount of difference observable would probably be immaterial, and nearly all the species which appear at the Lighthouses and Lightships could most likely be referred to one or other of the

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categories represented by the eight which have been chosen for particular investigation.

Regarding as a whole, the work on Migration begun by the first Committee appointed at Swansea in 1880 to obtain 'Observations on the Migration of Birds at Lighthouses and Lightships' after the Association had become acquainted [1] with the preliminary inquiry instituted in 1878 by Messrs. Cordeaux and Harvie-Brown, and continued for many years, until it took the shape of a Committee to make a Digest of the observations so collected (which Digest was presented at Liverpool in 1896), and then in its present form to work out the details of these observations, it may be stated as another important result of the inquiry that the fact of Bird Migration being for the most part carried on by night, which for a long while had been only surmised, must now be accepted as proved. The establishment of this fact is a very considerable gain, for though it may tend rather to obscure than enlighten us for the time as to the means whereby birds are able to direct their course on their wonderful nocturnal journeys, several theories to explain that mystery are thereby shown to be unsound, and, these being thus eliminated from the inquiry, its limits are by so much narrowed.

That investigation of the subject of Migration in general is far from being exhausted will be very evident to everyone. Some branches of it, indeed, are not touched at all, being precluded by the conditions of the inquiry, which (extensive as it has proved) was limited to observations at Lighthouses and Lightships, and thereby shut out all consideration of the very interesting question of the distribution of Migrants in the interior of the country after their arrival.

It follows that the investigation will have to be reopened, and that, it is to be hoped, at no distant time. The last thing your Committee would wish is to discourage the prosecution of observations, but they feel bound to express the opinion that no great advance of our present knowledge of the subject seems likely to be made until new methods are applied. What they should be it is impossible to suggest, but those used at present appear to have reached their limit. Meanwhile your Committee regards with much gratification the efforts made in several foreign countries, and especially in Denmark and in the United States of America, to obtain observations from their light-stations, while the recent establishment at Rossitten in Germany of an Ornithological Observatory is a hopeful sign.

Lastly, your Committee cannot present this, their final, Report without again recording the uniformly constant assistance received from the Corporation of the Trinity House and the Commissioners of Northern and of Irish Lights, without whose cordial co-operation nothing could have been done. Nor is it fitting that this Report should be closed without an acknowledgment of gratitude for the countenance so long extended by the British Association to the object of the inquiry, and the material support from time to time received in furtherance of the same—support which your Committee know would have been often more liberally granted had the funds of the Association permitted.

[1] *Report of the British Association*, 1880 (*Swansea*), p. 605; *Zoologist*, 1880, May, pp. 161–204; *Proc. Nat. Hist. Soc. Glasgow*, Sept. 30, 1879, p. 140.

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Statement furnished by Mr. Wm. Eagle Clarke.

Herewith I submit histories of the various migrations performed by the Starling and the Rook; species whose movements present special points of interest, while those of the former are of a more complex nature than is to be found in any other British bird.

My thanks are accorded to Professor Collett, of Christiania, and to Herr Knud Andersen, late of Copenhagen; and also to several British ornithologists (whose names are duly mentioned in the histories) for information afforded.

As this is the final instalment of my work for the Association, I desire to make the following remarks:

The 'Digest of Observations' submitted in 1896 has been abundantly and thoroughly tested during the progress of the subsequent work, and its accuracy has practically remained unshaken. A few modifications may be necessary, but they are of such an unimportant character as to need no mention here.

As regards the treatment of the movements of species, the plan devised aims at furnishing complete histories of each and every movement (and the various conditions &c. under which they are performed) of a few birds, carefully selected so as to include every type of British migrant; a comprehensive method of treatment never before attempted, I believe, for any species of migratory bird, British or foreign.

The consummation of this ideal has, however, presented exceptional difficulties; due chiefly to the fact that some of the movements are habitually performed under conditions which enshroud them in all but complete obscurity, indeed often in complete obscurity. Their elucidation has demanded an infinite amount of research ere results which were entirely satisfactory could be arrived at, for not a single statement made in the histories is of a hypothetical nature, unless it is clearly implied to be such.

Before concluding, I wish to express my acknowledgments to the members of the Committee for the honour they did me in 1887 in entrusting to my charge the preparation of the results obtained through this great inquiry; and also for the confidence they have since unfailingly reposed in me. To the late Mr. Cordeaux and others my special thanks are due for much valuable advice and encouragement; without the latter incentive I doubt much if I should ever have ventured to undertake so great and important a piece of research, or should have accomplished it.

Finally, I would state that although the work is fittingly concluded, so far as the British Association is concerned, the subject is by no means exhausted; and that I intend to continue the investigations in the hope of being able to add something to what has already been accomplished.

The Migrations of the Starling (*Sturnus vulgaris*).

The Starling is a summer visitor to Northern and much of Central Europe, and a winter visitor to Southern Europe and Northern Africa. In the British Isles it is a resident, a partial migrant, a winter visitor, and a bird of passage.

The migrations of the Starling observed in Great Britain and Ireland are of a singularly varied nature, being performed with great frequency and at all seasons. These remarkable characteristics in the movements of

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a well-known and familiar bird are due to a number of causes—among others, to its gregarious and desultory nature, the varying degree of its migratory instincts in different parts of the British area, its dependence upon supplies of food which not only change with the season but from year to year, and to the fact that it is double-brooded; peculiarities which result in innumerable movements, many of them of a partial or wholly irregular nature.

In addition to these, there are the regular migrations performed by the Starling (1) as a migratory species in Britain; (2) as a winter visitor to our isles from Northern and Central Europe; (3) as a bird of double passage, traversing our shores when *en route* between Continental summer quarters and winter retreats; and, finally (4) there are winter movements—partial migrations within the British area and emigrations to the Continent—dependent upon and varying with the severity of the season.

The data amassed relating to these numerous irregular and regular movements are extraordinarily voluminous, and their study has presented problems for solution of an exceptionally complex nature—more so than those appertaining to any other species hitherto treated.

As a resident species the Starling is widely distributed over our islands, its range extending from the Shetland and other northern isles [1] southward to the English Channel. In many of the northern and in the more elevated portions of the mainland of Britain the bird is migratory, being entirely or partially absent during the autumn and winter months.[2]

This variability in the migratory habit is also manifest in many districts of England. It may in most cases depend upon the distribution of food-supplies; but this does not explain all, for there are certain counties in south-western England (Cornwall and Devon) in which the Starling has only recently become a breeding species, and is still chiefly a winter visitor.

In Ireland the peculiarities in seasonal distribution of native Starlings are very similar, and the species is mainly a winter visitor to the south and west. An interesting and important fact is that in Ireland winter visitors from Great Britain and the Continent far outnumber the Irish birds.

Summer and Autumn Movements of British Starlings.—These take the form of (1) local migrations within the British area, and (2) of emigrations of native birds to winter quarters beyond our shores.

1. *Local Migrations.*—These begin in the early summer; indeed, as soon as the young, especially those of the broods first cast off, are able to shift for themselves. Sometimes as early as the first week in June parties composed of youngsters begin their wanderings; but it is usually about the middle of the month that such flocks are commonly observed. Even thus early the maritime districts, the light stations, and islands lying off the coast are sometimes visited.

Later in the summer both old and young gather together and form large flocks. Movements of a more definite nature are then undertaken, at first probably in search of fresh feeding-grounds, and finally for winter homes.

The coast with its vicinity is largely visited, especially the southern and western seaboards; and when summer is past the Hebrides and other

[1] In North Ronaldshay, one of the outermost and exposed of the Orkneys, only a few remain for the winter.

[2] At Halmyre, a moderately elevated district, in Peeblesshire, about 75 per cent. leave (Laidlaw). At Pitlochry, in Perthshire, all depart (Macpherson).

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islands (including Scilly) and Ireland are also sought for the winter. These movements commence in some seasons as early as the end of July,[1] and are in progress throughout the autumn. Ireland receives considerable numbers of immigrants from England, Scotland, and Wales towards the end of August and onwards.

Later in autumn these movements merge into those of the Continental hosts also seeking winter retreats in various parts of our islands.

2. *Summer and Autumn Emigration.*—Not only are winter quarters sought by our native Starlings within the British area, but many travel much further to find retreats in South-Western Europe. Thus a number of our British-breeding Starlings are summer visitors to our islands.

Late in July, during August, and up to the middle of September (before the Continental birds appear on our shores) emigrant Starlings depart from the south coast of England, and are observed crossing the Channel towards France, sometimes in company with Wheatears, Sedge Warblers, Song-Thrushes, Meadow Pipits, Skylarks, Curlews, and other species. These movements of departure are performed during the night or the earliest hours of the morning, and hence for the most part escape notice; but I have received during the past two years much valuable information regarding them from the Eddystone Lighthouse, the situation of which is singularly favourable for the making of such observations. Nearly all the Starlings (and other species) which meet with an untimely end at the lanterns at this season are birds of the year, a circumstance, however, to which undue significance should not be attached; for we must remember that the majority of the emigrants are young, indeed only a few weeks old, and it seems natural that they should fall easier victims to the attractions of the lanterns than older travellers with more experience.

Some of these native emigrants are probably of Irish origin, but their departure is likewise difficult to detect. There are, however, nocturnal movements (and emigratory movements are eminently performed by night) of Starlings and other birds during the latter part of July and in August, which seem to indicate that this species quits Ireland in the late summer and early autumn for more southern winter quarters.

It is possible that some Starlings may cross the English Channel in the daytime. There is, however, but one record of such a movement in the returns,[2] and during a five weeks' residence at the Eddystone in September and October 1901 I never saw any diurnal emigration on the part of this species, though many thousands crossed in the night and earliest hours of the morning.

Autumn Immigration from Central Europe.—The first arrivals from the Continent on our coasts in the autumn come from the east, and are doubtless emigrant summer visitors from Western Central Europe. These visitors cross the southern waters of the North Sea by a more or less direct east-to-west passage, and appear on the coast of England from the Humber southwards to the Channel.

These immigrations set in with great regularity during the last week of September,[3] reach their maximum volume in the last three weeks of

[1] At the Tuskar Rock, off the S.E. coast of Ireland, on July 27, 1894, several Starlings were observed proceeding in a north-westerly direction.

[2] At the Varne Lightship (Straits of Dover) on September 18, 1887, twenty passed from N. to S.S.E. at 7 A.M.

[3] The earliest date chronicled is September 21, 1880, but the initial date for other years follows closely thereon.

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October, and usually cease with the early days of November, but in some seasons there are arrivals until the middle of the month.[1]

As an illustration of the magnitude of these inpourings, it may be stated that they have been recorded for as many as twenty-one days during October, and that the chief 'rushes' often cover several successive days, and affect the entire coastline from the Humber southwards. The passage is chiefly performed during the daytime, and not unfrequently lasts from early morning until dusk;[2] but there are records which *may* refer to a night passage along this route.

Like other immigrations along this route, the direction of flight varies, being from direct east to west at its centre about the mouth of the Thames, to the south-west off the coast of Kent, to the north-west on the Norfolk coast, and to the north-north-west at the mouth of the Humber. Occasionally at the more southern stations and at the Varne Lightship, in the Straits of Dover, Starlings and Rooks are recorded as proceeding N.N.W., and as coming from the coast of France.

The species which have been observed migrating from east to west on the same dates as the Starling are Rooks, Larks, Tree Sparrows, Chaffinches, and Lapwings.

Many of these immigrant Starlings from Central Europe winter in various parts of England[3]; many, too, pass along our southern shores: some to cross the English Channel at various points on their way to retreats in South-Western Europe; while others proceed to Ireland, where they arrive on the coast of Wexford as a centre after passage across St. George's Channel. Vast numbers of Starlings pour into Ireland by this route between the latter half of October and the middle of November, the passage on some occasions lasting for several successive days.[4]

Autumn Immigration from North-Western Europe.—The arrival on our shores in the autumn of the Starlings quitting their summer homes in Scandinavia does not begin until about two weeks after the first appearance on the coast of England of the emigrants from Central Europe.

The earliest immigrants from the north appear on the north-east coast of Great Britain during the first half of October,[5] and the main body arrives late in the month. There are also important inpourings during the early part of November, and in some seasons laggards have made their appearance as late as the 21st of the month.[6] A pronounced feature of these movements is that the birds arrive in a series of 'rushes,' there being no immigration of a straggling nature chronicled.

During these movements Starlings are recorded as arriving on the east coast from Shetland to, and sometimes beyond, the Humber. A number, too, reach the Atlantic seaboard and the Hebrides, occurring not unfrequently as far west as the Flannan and Monach Isles.

[1] Latest at the Corton Lightship on November 17, 1880.

[2] At the Leman and Ower Lightship on October 24, 1884, a flight, estimated at 5,000, passed landwards at 5 P.M., and of these fifty struck the lantern and were killed.

[3] It is highly probable, indeed almost certain, that some of these Central European birds winter in latitudes *north* of their summer homes.

[4] In 1884 it was observed for eight consecutive days (October 15–22) at light-stations off the coasts of Waterford, Wexford, and Wicklow.

[5] The earliest dates recorded are as follows: October 1, 1886; 3, 1884; 6, 1883; 9, 1882; 15, 1880; 16, 1885; 18, 1887; 19, 1881.

[6] Professor Collett informs me that most of the Starlings leave Southern Norway in the course of October, and are common at the lighthouses during that month and the early part of November.

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Like other visitors from the north, these immigrant Starlings appear on our shores during the late hours of the night and early hours of the morning; the other species arriving in company simultaneously being Redwings, Fieldfares, Song-Thrushes, Blackbirds, Ring Ousels, Wheatears, Hedge Sparrows, Redbreasts, Wrens, Goldcrests, Redstarts, Bramblings, Siskins, Chaffinches, Larks, Short-eared Owls, Snipes, and Woodcocks.

These autumnal immigrations from the north-west are followed by overland movements westwards and southwards in search of winter quarters within the British area; the western, southern, and south-western districts of England, the Hebrides and other western isles, and Ireland affording specially favoured haunts. Ireland is entered from the north and north-east; the birds travelling by way of the Hebrides and the west coast of Scotland, or (after an overland flight across Northern Britain) from the Galloway coast.

Autumn Passage from Northern and Central to Southern Europe.—Vast numbers of the Starlings which arrive on our shores in the autumn from both Northern and Central Europe do not remain to winter with us, but proceed on passage to retreats in South-Western Europe.

These passage movements follow (probably at once in the case of the majority of the migrants) the arrivals from the Continent, and are in progress from the latter half of September (on the past of the Central European birds) until the third week of November. The course of the birds from the east (Central Europe) has already been traced along the south coast of England and across the Channel. The birds of passage of northern origin proceed southwards down both the east and west coastlines (including the Hebrides), but more especially the former, and finally depart as emigrants,[1] crossing the Channel at various points between Kent and Scilly.

Some idea of the magnitude of these movements may be gathered from the fact that on the night of October 12 and the early morning of October 13, 1901, vast numbers of Starlings, evidently of Continental origin, passed the Eddystone, going southwards for ten hours and a half without a break. Sixty-seven perished at the lantern, and great numbers, after striking, fell over into the sea and were drowned.[2] Some of these autumnal visitors belong to a race which is characterised by having a purple head and throat and green ear-coverts. This form occurs on our south-eastern and southern coasts, and as I have failed to match them with British and Scandinavian specimens obtained at the same season, I think it is probable that these birds come to us from the east.

During the autumnal migratory movements Starlings sometimes considerably overshoot our western limits, and are observed far out in the Atlantic. At the end of October 1870 a large flock was encountered 300 miles west of Scilly,[3] and on October 23, 1876, one alighted on H.M.S. *Alert* between Capes Farewell and Clear, when 517 miles from the latter.[4] At Eagle Island, off Mayo, on October 31 and November 1, 1886, several thousands are said to have passed westwards over the Atlantic.

Winter Movements.—The winter movements of the Starling are

[1] It is possible that some of our British Starlings may also participate in these emigrations by joining the ranks of the Continental birds and departing with them for the south.

[2] *Ibis*, 1902, pp. 252–255.

[3] Rodd, *Birds of Cornwall*, p. 292.

[4] Feilden, *Zoologist*, 1877, p. 469.

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attributable to the same cause and are performed under identical conditions as those undertaken by the Song Thrush, Skylark, and Lapwing, which have been fully treated in the summaries on these species, and the subject generally in the 'Digest of Observations.'[1] It is, therefore, only necessary to touch somewhat briefly on these forced migrations of this bird.

Although a species which is much affected by severe weather, and especially snow, inasmuch as its ordinary food then becomes difficult and sometimes impossible to procure, yet many of our resident Starlings remain in their accustomed haunts throughout periods of such extreme severity that great numbers perish from hunger. Others, along with species similarly affected, move to the coast, especially the west and south-west coasts of England and Ireland. Ireland is also sought by considerable numbers of emigrants, which arrive from the north-east and east on the occasion of each great outburst of cold in Great Britain. But even on the south-west coast of Ireland, where the climatic conditions are more favourable than elsewhere within our area, great numbers perish in severe seasons such as those of 1881 (January), 1882 (December), and 1895 (January to March). Many, too, cross the English Channel and proceed southwards in search of more genial haunts on the Continent.

I am of opinion that these migrants are chiefly composed of our winter guests from the Continent, for careful observations made during seasons of exceptional severity lead me to believe that most of our resident stock do not leave their usual haunts, and may be seen daily on the approach of dusk proceeding in numbers to their usual winter roosts.

Spring Immigration from Southern Europe and Passage to Northern and Central Europe.—The spring immigrations of the Starling relate to the return of (1) British summer visitors and of (2) the birds of passage on their way north and east from their accustomed winter quarters in South-Western Europe, and of (3) the refugees which have been forced to flee our country through the pressure of winter conditions.

The first Starlings to appear on the southern coastline of England are probably those birds which quitted our shores earliest in the autumn, namely, the British summer visitors, which return to their breeding haunts about the time that the first of the spring immigrants arrive on the south coast, *i.e.* usually during the last week in February.[2] These return movements continue at intervals during March and the early part of April, the 12th being the latest date on which they have been chronicled. The later migrants are, no doubt, birds of passage, which after arrival proceed along both the east and west coasts (mainly the former), *en route* for summer quarters in Northern and Central Europe.

The immigrants appear on the south coast during the night and early morning, and travel in company with (in addition to the species already named) Redwings, Ring Ousels, Wheatears, Redstarts, Blackcaps, Chiff Chaffs, Willow Warblers, and Swallows.[3]

[1] *Rep. Brit. Assoc.*, 1896, p. 473.

[2] The earliest record is for February 19, 1903, when great numbers passed the Eddystone in flocks, coming from the S. and S.S.E. They commenced to arrive at 7 P.M., and the passage lasted, with breaks, until 5 A.M. Many were killed at the lantern, and great numbers struck and fell over into the sea. The other species participating in this great return movement were Mistle Thrushes, Song Thrushes, Skylarks, Lapwings, and others.

[3] On some occasions Starlings and other species (Skylarks, 'Black Crows,' Rooks, Goldcrests, and Wild Ducks) have been recorded as arriving on the south-east coast

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Starlings have been noted as spring immigrants on the south-east coast of Ireland at dates ranging from the third week of February to mid-April. This indicates a return of Starlings which have either quitted Ireland for the winter, or of birds of passage on their way north, or, again, most probably of both, for the dates are wide-ranging, sufficiently so to cover both the return of native birds and the movements of birds of passage. During the later dates, these Irish immigrants are sometimes accompanied by various summer visitors and birds of passage—Wheatears, Ring Ousels, Redwings, &c. Similar movements at the Hebrides are recorded as late as April 14.

Spring Emigration to Central Europe.—The spring emigration from the coast of south-east England eastwards across the southern part of the North Sea of the Starlings which are returning to summer quarters in Central Europe, after wintering in the British Isles and in South-Western Europe (the latter being birds of passage), is very little in evidence as compared with the great immigratory movements on the part of these same birds during the autumn.

It comes under observation, however, at the great fleet of lightships stationed between the Wash and the mouth of the Thames, and takes place between the middle of February and the end of March. There are no April movements chronicled, nor have other species been recorded as emigrating in their company. The observations on these return movements relate to the daytime only.

Spring Emigration to North-Western Europe.—The return movements to their summer haunts in Scandinavia of those Starlings which have wintered in the British Isles, or have traversed our shores on their way from winter quarters in South-Western Europe, do not, as is the case with all emigratory movements, find a very marked place in the records. They are performed at night, and under favourable weather conditions, between mid-March and the end of April,[1] and are observed chiefly at stations on the north-east coast of Great Britain and at the Orkneys and Shetlands, the other birds noted as emigrating at the same time being Skylarks, Blackbirds, Lapwings, and Goldcrests.

The latest record was chronicled at the Isle of May on April 28, 1886, when at 10 P M. Starlings appeared during a 'rush' of migrants (Wheatears, Redstarts, Whitethroats, &c.)

The Starlings which winter in Ireland begin to emigrate about the middle of February, and in some seasons the movements are in progress until the middle or end of March.[2] Those wintering in western Britain and certain of the Hebridean Islands (such as Tiree), leave at dates ranging from the middle of February to the end of March.

of England in the spring (see *Report*, 1883, p. 57). In the *Zoologist* for 1870 (p. 2140) it is recorded from Aldeburgh that during the second week of March immense numbers of Rooks and Starlings were almost constantly arriving 'from over the sea.' In the same Journal for 1902 (p. 87) Mr. Gurney states that on March 23, 1901, some were picked up dead on the beach at Yarmouth, along with Rooks, 'which had lost their lives in crossing.' This last record *may*, however, refer to spring emigration, the disaster occurring after departure from our shores. Similar but more regularly recorded movements are performed by the Rook, to which reference may be made.

[1] Professor Collett informs me that Starlings arrive singly in southern Norway about the middle of March, and in flocks at the beginning of April.

[2] On March 26, 1887, the Starlings and Thrushes wintering on Tearaght left the island. On April 14, 1885, thirty, probably on passage north, struck the lantern at Copeland Island.

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Summary of the Migrations of the Starling.—The various movements of the Starling may be conveniently summarised as follows :

1. In June, sometimes early in the month, the young of the first broods of our native Starlings gather together and lead a roving life, during which they visit the coast and elsewhere.

2. Later in summer both old and young form flocks and wander afield in search of food, and in the autumn many of these wanderers seek winter quarters in the west and south of Great Britain and Ireland, some numbers of the British birds emigrating to Ireland for that purpose.

3. A portion of our native Starlings, especially those inhabiting the more northern and elevated districts, quit our shores in the late summer and early autumn to winter in South-Western Europe &c. Such birds are essentially summer visitors to the British Isles.

4. During the autumn (late September to early November) vast numbers of Starlings arrive on the south-east coast of England from Central Europe : many to winter in England and Ireland, others to proceed, as birds of passage, to South-Western Europe for the cold season.

5. Later in the autumn (October and November) considerable numbers of immigrants from Scandinavia arrive on our northern and north-eastern shores, many of which winter in Great Britain and Ireland, while others proceed on passage to winter in Southern Europe.

6. During these autumnal movements Starlings sometimes overshoot our western limits, and are observed far out in the Atlantic.

7. On the advent of severe cold the would-be winter residents (chiefly our Continental guests) fly to the southern and western districts (especially the coasts) of Great Britain and Ireland, and in winters or periods of exceptional severity many quit our isles for more southern asylums on the Continent.

8. In February the birds inhabiting the more northern and elevated districts in our isles begin to return to their summer quarters.

9. The earliest days of spring, and even those preceding (February and March), witness the return from their winter quarters in Southern Europe of the Starlings which are summer visitors to the British Isles.

10. About the same time the refugees which quitted our isles during the winter return to our shores.

11. Later (March and April) the birds of passage, which also wintered in Southern Europe, arrive on the south coast to travel by way of our shores to their breeding haunts in Central and North-Western Europe.

12. Early in spring, too (mid-February and during March), the Central European birds which have wintered with us depart eastwards for their summer homes on the Continent.

13. Later (in mid-March and during April) the Scandinavian birds which have passed the winter in our islands take their departure for their northern summer haunts.

The Migrations of the Rook (*Corvus frugilegus*).

The Rook is a summer visitor to North-Western Europe, and is migratory to a considerable extent in the central portions of the Continent.

From both of these areas the bird seeks Great Britain in the autumn as a winter retreat, departing in the spring.

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Some Rooks leave the south-east shores of England in the autumn, and though such emigrations, or passages, are somewhat scantily recorded, yet the corresponding return migrations in the spring are regularly chronicled. A similar spring immigration is also observed on the south-east coast of Ireland. The above-mentioned movements constitute the *regular* migrations of the Rook as observed in Great Britain and Ireland.

In addition, some irregular migrations and intermigrations come under notice, for the bird is much given to wandering, especially after the close of the breeding season and during the summer, when flocks consisting of old and young visit the vicinity of the coast and some of the neighbouring islands; food of a particular nature being, presumably, the main incentive for these roving movements.

In Ireland, with the exception of the spring immigration already mentioned, the movements, both local and intermigratory, are to be regarded as being only of a partial or irregular nature.

In severe winters Rooks, in small numbers, have been recorded as seeking certain of the Outer Hebrides in search of more genial quarters than those afforded by the mainland. To others of these islands it is a regular winter visitor.

Apparently erratic movements out into the Atlantic have been known to take place in the autumn.

Although one of our most familiar birds—a species known to all observers—yet there is a lack of information regarding the movements of the Rook that is not a little surprising: further and striking proof of the great difficulties which enshroud the whole subject of bird-migration.

Autumn Immigration from Central Europe.—This is by far the most important of the autumn migrations of the Rook witnessed on our shores, for it is from Central Europe that we receive the great majority of the birds which winter in Britain.

The immigrants arrive on the south-east coast of England, from the Humber to the coast of Kent, at dates ranging from the latter half of September to mid-November,[1] the greatest numbers appearing during late October, when these movements are often in progress for several successive days, during which vast numbers pour in upon our shores.[2]

The direction of the flight varies, being usually from direct east to west at or about the mouth of the Thames (and sometimes on the coasts of Norfolk and Kent) to north-west and north-north-west on the coast of Suffolk and northwards. Occasionally numbers are observed off the mouth of the Thames and east coast of Kent moving north-west across the Straits of Dover, as if coming from the north-east coast of France. On reaching our shores the immigrants proceed inland in search of winter quarters.

The movements are only observed during the daytime, usually between 9 A.M. and 4 P.M.; and the birds pass the lightships in straggling flocks, or sometimes in small parties (even of two or three individuals), and frequently immense numbers pass in a single day.

The most frequent companion of the Rook on these occasions is the Daw, though always in smaller (usually much smaller) numbers than its congener; the other species also migrating in company, or at the same

[1] The first recorded appearance is September 16 in 1880.

[2] In October 1884 the migrations covered twenty-two days.

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time, being Grey Crows, Carrion Crows, Starlings, Skylarks, Chaffinches, and Tree Sparrows.

Mr. Caton Haigh, who is favourably situated on the north coast of Lincolnshire for observing these immigrants, remarks that the parties sometimes consist entirely of old birds; sometimes of old and young, and sometimes, so far as he was able to determine, wholly of young birds.

Autumn Immigration from North-Western Europe.—The immigration from Northern Europe is far from being extensive. Rooks from Scandinavia[1] appear in the Shetlands and at some of the Orkneys (North Ronaldshay in particular) from the middle of October to mid-November. They arrive during the night, sometimes in fairly large flocks, and often remain for a short period before proceeding southwards.[2]

On the east coast of the mainland of Great Britain the arrival of these northern immigrants does not seem to have been observed; but passage movements southwards performed during the daytime are recorded as far south as Flamborough Head. Similar migrations are witnessed on the west coast of Scotland, chiefly at the Hebridean stations, which likewise follow the arrivals from the north. These diurnal migrations are probably passage movements to British winter quarters, and they sometimes extend as far westward as the Flannan and Monach Isles. The Rook is a winter visitor to Barra and probably to some other of the Hebrides.

The autumn immigrants from both east and north settle down for the winter in Great Britain—chiefly, I believe, in eastern England—and do not, as far as we know at present, proceed southwards of the British area after arrival on our shores.

Autumn Emigration from Britain.—At the Goodwin Lightships, on several occasions during September and October,[3] Rooks, sometimes in considerable numbers, are recorded as crossing the Straits of Dover in the daytime, in an easterly and south easterly direction, as if proceeding to the coasts of Belgium and France. These records are of considerable interest when considered in connection with the more regularly observed return movement which occurs in the spring. The early date on which some of these migrations are chronicled would seem to indicate that the emigrants are British birds, for they are dated prior to the arrival of the earliest autumn visitors from the Continent.

Spring Immigration to Britain.—During late February, throughout March, and sometimes in the first half of April,[4] considerable numbers of Rooks, occasionally accompanied by Daws, Starlings, and Skylarks, arrive during the daytime on the south-east coast of England between Norfolk and Kent, the immigrations on some occasions lasting for several successive days.[5]

[1] Professor Collett informs me that the Rook, which is not an abundant species in Norway, mostly leaves that country for the winter.

[2] Mr. Thomas Henderson, junior, of Dunrossness, tells me that during long-continued southerly gales he has often seen the immigrant Rooks rise in a flock to a considerable height, as if anxious to be off, and then settle down again. They leave Shetland for the south as soon as favourable conditions set in.

[3] The earliest of these autumn departures is dated September 9, and the latest October 30.

[4] The earliest record is for February 23, and the latest for April 18.

[5] The late Sir Edward Newton made a number of interesting observations on these movements as witnessed by him at Lowestoft. He writes thus on one of them which occurred on March 31, 1889: 'This morning, while sitting in the house, I heard Rooks and Jackdaws. On looking out I saw flocks of about one hundred coming in very high from the S.E. A few minutes later I again heard Rooks and

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These, or perhaps we should say some of them, are, no doubt, the return movements to British haunts of the emigrants observed leaving our shores in the autumn. Other individuals, especially the late arrivals, may be on passage to the Continent, the corresponding autumn passage southwards on the part of foreign immigrants is not obviously recorded in our data, though it possibly occurs.

Spring Emigration to Central Europe.—As the reverse migration was the main one of the autumn, so is this the most important one of the spring.

The first departures of the Rooks which have wintered in England are those for Central Europe. As early as the second week of February (the 10th being the earliest record) these great emigrations eastwards set in, reach their maximum during March, and are much in evidence until the middle of April, the 23rd of that month marking their extreme limit in the observations. During this prolonged period vast numbers of emigrants are observed at the lightships between the Humber and the mouth of the Thames (occasionally at the Straits of Dover), passing to the south-east and east during the daytime, from 6 A.M. onwards, and sometimes flying very high; Grey Crows, Daws, Skylarks, Tree Sparrows, and Chaffinches not unfrequently departing at the same time.

Prior to their departure certain of these emigrants have been observed passing southwards, occasionally accompanied by Grey Crows, on both the Yorkshire and Norfolk coasts, *en route* for some particular points of embarkation for the crossing of the North Sea.[1]

Spring Emigration to North-Western Europe.—The Rooks from Scandinavia which have wintered in our islands return north in March and April, and (as in the autumn) are mainly observed on passage in the Orkneys and Shetlands. Some appear in these northern islands as early as the first days of March, but the chief movements take place during its latter days and the early days of April, though a few are seen as late as the end of that month.[2] They arrive during the night, occasionally in large flocks, and are sometimes accompanied by Grey Crows and Daws. The emigrants appear at stations widely scattered over both Orkney and Shetland, and usually tarry for a few days before proceeding northwards.

There are only a few records relating to these movements northwards on the east coast of Britain, and it would seem as if they but rarely came under notice at any of the mainland stations. Rooks in small numbers are, however, observed annually at the Hebrides, including the Flannan Isles, on passage during March and April. They occur at the Færoes on passage about the same time (Andersen), and arrive in Norway during the latter part of March or beginning of April (Collett).

Irish Migrations.—The regular migrations of the Rook witnessed in Ireland are of an extremely limited nature, and relate to certain arrivals in the spring. Ireland does not appear to be visited by Continental birds as a winter resort, and hence the movements observed there are chiefly

Jackdaws, and again saw another flock, also very high, flying northwards; they were occasionally toying and circling as one sees them in summer and autumn.'

[1] At Somerton, on the Norfolk coast, on March 20, 1886, Rooks were flying due south in a continuous stream from 10.30 A.M. to 6 P.M., never fewer than 1,000 being in sight at the same time. (*Report*, 1885, p. 47.)

[2] Stragglers have been observed as late as May 16, and some of a party which arrived in Unst on March 4, 1901, remained until July 23 (T. E. Saxby), and probably did not proceed beyond the limits of the British Isles.

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of a local or irregular character. There are, however, occasional inter-migrations with Great Britain.

Irish Autumn Movements.—During October and November in some years Rooks have been recorded as arriving on the south-east coast, but these immigrations are so irregular and unimportant as not to merit further notice at present. Such passages on the part of other species are among the best observed and most interesting of the Irish movements, and the absence of the Rook presents a remarkable negative feature, especially so since nearly all the species from Central Europe which winter in England find their way to Ireland by this route in considerable numbers.

Rooks have also been occasionally observed in October at the islands (Rathlin and Maidens) off the north-east coast, coming from the direction of the mainland of Scotland, and sometimes 'rushes' are recorded.

Irish Spring Movements.—The chief feature in the migrations of the Rook as observed in Ireland is the *regular* spring immigration observed (during the daytime) on the south-east coast, between the latter half of March and the third week of April—the movements indicating that a corresponding autumn emigration most likely takes place, though such has, as yet, entirely escaped notice. It is impossible to determine the precise nature of these movements. They may relate to birds returning to their native homes, or to birds of passage traversing the Irish coast on their way northwards. We have, however, no further information concerning them, and the question must remain open.

There are occasional records of spring departures. These are witnessed at Copeland Island, Rathlin, and the Maidens, off the north-east coast, where occasionally Rooks have been observed moving towards Scotland in April. These are probably return migrations of the birds sometimes observed at the same stations moving in an opposite direction in the autumn.

Apparently Erratic Movements to the West.—In the late autumn large numbers of Rooks have occasionally been observed moving westwards beyond the British Isles and over the waters of the Atlantic, wherein many perish, and whence others, having retraced their flight, arrive in an exhausted condition on our furthest western shores.

Perhaps the best instance on record of such movements occurred in October 1893, when late in the month vast numbers (estimated at from 5,000 to 6,000) arrived at Scilly from the south-east, accompanied by a few Daws, and proceeded in a westerly direction. About the same time a large flight of Rooks, presumably the same birds, were met with by steamers out in the Atlantic some 300 miles west of Ireland, and in such an exhausted condition that some fell into the sea and were drowned, being too weak to retain their foothold on the vessel on which they had alighted. It is said that these birds avoided the outward-bound steamers, but sought those which were approaching the land. As there was nothing unusual in the weather at the time of the birds' appearance in Scilly, they were certainly not on this occasion blown out to sea, a theory which has been advanced to explain similar flights.

Return movements of considerable numbers of Rooks from the Atlantic have several times been recorded at stations on the west coast of Ireland. In 1884, between November 2 and 25, large numbers

[1] J. H. Jenkinson, *The Field*, March 3, 1894.

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arrived at Tearaght Island and at the Skelligs, off the coast of Kerry, for several days, either in flocks or at intervals.

Again in 1887, between October 21 and November 23, they appeared at the same stations, also in numbers and direct from the Atlantic. Similar movements were witnessed in 1888 and 1890, chiefly in November, at Tearaght and at Slyne Head, Galway.

In the middle of November 1893 (soon after the great movement observed at Scilly), some 4,000 or 5,000 appeared in the Island of Lewis, arriving in an exhausted state, and great numbers were washed ashore on the west side of the island.[1] It is worthy of remark that actual occupancy of a new 'Rookery' took place within the castle grounds of Stornoway, Lewis, very shortly after this phenomenal invasion was first recorded in *The Field* by Mr. Duncan Mackenzie.[2]

Summary of the Migrations of the Rook.—1. Partial and irregular movements on the part of young and old begin at the close of the nesting season and continue throughout the autumn.

2. Vast numbers of Rooks from Central Europe arrive on the south-east coast of England (coming from the east and south-east) between the latter half of September and the middle of November, to pass the winter in the eastern counties of England. This is the main autumnal movement.

3. From the middle of October to the middle of November emigrants from Scandinavia arrive on our northern shores and remain to winter in Great Britain. They are chiefly observed as immigrants in Shetland and Orkney, and, on passage to their British retreats, on the north-east and north-west coastlines.

4. In severe winters some emigrate from the mainland of North Britain and are observed in small numbers in the Western Isles (Lewis &c.)

5. Late in February, during March, and sometimes early in April numbers of Rooks arrive on the south-east coast of England from the Continent, moving in a westerly and north-westerly direction during the daytime. These are most probably returning British emigrants whose departure in the autumn has escaped notice.

6. Early in February and until mid-April the Rooks from Central Europe which have wintered in England depart from the south-east coast for their summer homes. This is the most important movement of the spring.

7. Throughout March and April the winter visitors to Britain from Scandinavia are observed, chiefly at the Orkneys and Shetlands, returning to their northern summer quarters.

8. The Irish movements are chiefly of an irregular and unimportant nature, and Ireland is not resorted to by the Continental visitors for winter quarters. In October and November in some years arrivals have been recorded on the south-east coast after passage across St. George's Channel; and there are occasional arrivals from Scotland at the islands off the N.E. coast. In spring there is a regular return migration witnessed on the S.E. coast between the latter half of March and the third week of April; implying an unobserved autumn emigration either of

[1] D. Mackenzie, *The Field*, April 4, 1894.
[2] *Annals of Scot. Nat. Hist.*, pp. 149-150.

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native Rooks or of birds of passage, or both. There are a few records of the return of Rooks to Scotland in the spring.

9. In the autumn of some years apparently erratic movements westwards over the Atlantic have taken place. During these many of the wanderers have been known to perish, while others have been observed returning, in an exhausted condition, on the west coast of Ireland, and of the Hebrides.

The State of Solution of Proteids.—Report of the Committee, consisting of Professor HALLIBURTON (*Chairman*), Professor WAYMOUTH REID (*Secretary*), *and* Professor E. A. SCHÄFER, *appointed to investigate the state of Solution of Proteids.*

THE test of solution employed in this research has been the production of a lasting osmotic pressure upon a membrane impermeable to the proteid when the pure solvent is exhibited on one side and the reputed solution on the other side of the membrane. A positive result by direct manometric observation is taken as indicating a condition of true solution, a negative result as indicative of a state of fine suspension of the proteid. The membrane used has been almost exclusively formalised gelatine supported in the pores of peritoneal membrane, fixed on a perforated metal support, and set in an osmometer in which continuous stirring for periods of six to eighteen days was possible.

The pressures were read daily with careful thermometric correction.

Ovalbumin, serum-albumin, and various globulins have chiefly been used for experiment, though work with other proteids is still in progress.

Since the molecular weights of proteids is uncertain, the results have been simply stated in the pressures in mm. of mercury for 1 per cent. concentration of the proteid in reputed solution as determined by analysis.

As the source from which all proteids are drawn must, by the nature of the case, be one heavily contaminated with other bodies, and as it is well known that proteids absorb other bodies in solution very strongly, attention has been largely directed to the purification of the material used for experiment. In some cases crystallisation may assist, but it is believed that thorough washing with salt solutions in which the crystallised or precipitated proteid is insoluble, is the best means for removal of adherent foreign substances. The purification of the material for experiment has been the most laborious part of the research.

The fact that solutions of similarly prepared samples of the same proteid (say ovalbumin) obtained from different sources (different batches of eggs) may give very different osmotic pressures per unit concentration of proteid, suggested that the pressure read in such cases is not due to the proteid in solution, but to some other body or bodies in true solution and present in variable amount.

If this is so, thorough washing of all such proteids, which in apparent solution at first give an osmotic pressure, should finally yield a fluid holding proteid, but giving no osmotic pressure.

This has been amply verified in the experiments, both in the case of ovalbumin and serum-albumin, and osmotic-pressure-free proteid 'solutions' have been prepared without great difficulty, and the proteid obtained dry by the vacuum pan for use in other experiments.

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An obvious objection to the above interpretation of the results is that the process of washing may so physically alter the proteid that, though originally in true solution, it reaches in the end a state in which it is only in suspension. This objection is much weakened by the fact that if the washings are collected, the salt removed from them, and the fluid concentrated in the vacuum pan (in which the temperature is not allowed ever to exceed 30° C.), a fluid is obtained free of proteid but giving a lasting osmotic pressure, though the washed separated proteid does not give any pressure. In other words, the substance or substances causing an osmotic pressure in the proteid 'solution' first obtained can be washed out and collected, and a solution so obtained is then found to give a pressure though containing no proteid, while the proteid from which it has been removed is no longer capable of giving a pressure.

It is interesting to observe that a plain gelatine membrane is permeable by the substance or substances in solution in the washings, and that only when osmotic-pressure-free proteid is added to the solution does the pressure stand steady for the full length of the experiment (nine days).

It is thought that this solution contains disintegration products of proteids, since bacterial action will soon cause a 'solution' of osmotic-pressure-free proteid to give a lasting pressure, and that the pressure exhibited by freshly prepared and unpurified 'solutions' of proteid is really due to adherent proteid metabolites in true solution.

The Zoology of the Sandwich Islands.—Thirteenth Report of the Committee, consisting of Professor NEWTON (*Chairman*), Mr. DAVID SHARP (*Secretary*), Dr. W. T. BLANFORD, Professor S. J. HICKSON, Dr. P. L. SCLATER, Dr. F. DU CANE GODMAN, *and* Mr. EDGAR A. SMITH.

THIS Committee was appointed in 1890 and has been since annually reappointed.

Since the last report two parts of the Fauna Hawaiiensis, published by the Committee, have appeared, viz. Vol. III. Part 2, 'Hemiptera,' by Mr. G. W. Kirkaldy, and Vol. III. Part 3, 'Coleoptera Caraboidea,' by D. Sharp.

The first set of the Diptera described by Mr. P. H. Grimshaw has been sent to the British Museum, Natural History.

The part of the Fauna Hawaiiensis dealing with Vertebrata is in the Press, and copy for two other parts is in hand.

The Committee asks for reappointment without a grant.

Coral Reefs of the Indian Region.—Fourth Report of the Committee, consisting of Mr. A. SEDGWICK (*Chairman*), Mr. J. STANLEY GARDINER (*Secretary*), Professor J. W. JUDD, Mr. J. J. LISTER, Mr. FRANCIS DARWIN, Dr. S. F. HARMER, Professor A. MACALISTER, Professor W. A. HERDMAN, Professor S. J. HICKSON, Professor G. B. HOWES, *and* Professor J. GRAHAM KERR.

THE Committee present the following Report by the Secretary, who has had charge of the work :—

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During the past year two parts of 'The Fauna and Geography of the Maldive and Laccadive Archipelagoes' have been published, *i.e.* Part IV., completing Volume I., and Part I. of Volume II. They contain reports by Mr. C. Forster Cooper on the Cephalochorda; by Mr. R. C. Punnett on Meristic Variation in the Cephalochorda; by Dr. Gadow and Mr. Stanley Gardiner on the Birds; by Mr. F. E. Beddard on the Earthworms; by Mr. W. F. Lanchester on the Stomatopoda; by Mr L. A. Borradaile on the Crabs of the groups Catometopa, Oxystomata, and Dromiacea, and on the Cirripedia; by Dr. M. Foslie of Trondhjem on the Lithothamnia, important reef-building algæ; by Professor Sydney J. Hickson and Miss Pratt, two most valuable and interesting papers on the Alcyonaria of the Maldives; by Sir Chas. Eliot, K.C.M.G., on the Nudibranchiata; by Mr. F. F Laidlaw on a Land Planarian, the first recorded from an oceanic atoll; and by Sir John Murray and Mr. Stanley Gardiner on the Lagoon Deposits.

Part II. of Volume II. is in the press, and will contain, among others, papers by Mr. Edgar Smith on the Shelled Mollusca, of which 381 are recorded; and by Mr. R. C. Punnett on the Enteropneusta, fourteen species and varieties, with an account of meristic variation in the group.

Reports are shortly expected on most of the other groups which have not already been dealt with. A list of the genera and the pelagic species of Foraminifera has been given in the report on 'Lagoon Deposits.' In view of the accounts published or in the press on the East Indian Foraminifera, and also of the necessary limitation of space, it is not proposed to give any further report. Mr. Cyril Crossland has undertaken to work out the Polychæta in conjunction with his own collection from Zanzibar. The group shows great variability, and the collections are both of very considerable size, similar in genera, and from two well-defined areas of the Indian Ocean, of which the physical features are known. As it is obviously greatly to the advancement of our knowledge of the group, I have agreed that the two collections shall be reported on together in a single paper, of which the first part has already appeared in the 'Proceedings of the Zoological Society.' I am myself at present engaged in preparing my report on the true Corals (Madreporaria), but the work is one of considerable difficulty, as at present practically nothing is known of variation in this group of animals.

Volunteers are urgently desired for the Hydroid Polyps, Actiniarians, Pteropods, Holothurians, and some other groups. It is not proposed to publish any detailed report on the whole pelagic fauna, as it would be foreign to the main objects of the expedition. The collection is of course open to specialists who desire to examine it for different groups of animals.

In addition to the papers enumerated above as published in the year 1902–03, I have concluded my article on the coral formations with a detailed description of the Maldive atolls and banks in Appendix B, and some concluding remarks on the food, life, and death of corals in Appendix C. So far as possible I have shown in the text and in a series of figures the present conditions of the Maldive atolls and reefs visited by my expedition. The surveys were made in comparison with the already existing charts. They do not pretend to *strict* topographical accuracy, but were such as the very limited means and time at our disposal enabled us to do. They were intended for comparison only; but being, I believe, fairly accurate, so far as specific islands, reefs, lagoons, depths,

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&c. are mentioned, will be, I trust, useful for a further comparison whenever the group is resurveyed by the Admiralty.

As the results of the expedition on the question of the formation of coral reefs, the investigation of which was the main object of the expedition, have now been published, I may be permitted to briefly summarise them.[1] I would, however, first express my very great indebtedness to Messrs. L. A. Borradaile and C. Forster Cooper and Captain Molony, of the ss. 'Ilealaee' for the very loyal and whole-hearted way in which they aided me in all the work.

In the first place, an accurate knowledge has been obtained of the largest and most extraordinary series of coral formations in the world, one situated too *at the present time* quite outside the influences of continental conditions. The physical features of the region have been examined, especially in respect to currents, while the biological conditions have been exhaustively studied both of the encircling reefs and of those within the banks, and both towards the ocean and the enclosed waters of the lagoons and banks. Owing to specially favourable circumstances it has been possible to throw considerable light on the rate of growth of corals and hence also of reefs. Special work was undertaken to investigate the seaward slopes of the reefs, the formation of lagoons, the action of boring and sand-feeding organisms, and the conditions affecting the land. Owing to this examination it has been possible to ascertain the changes in progress in the different atolls and banks, and so by deduction to infer the later stages in the formation of the coral reefs of the region.

Unfortunately the means available for the expedition were not sufficient to allow of detailed work being undertaken below 50 fathoms, which was shown to be the *extreme* limit in depth of the so-called *reef-building* corals, those forms which at present are found living on the surfaces of the reefs.[2] A few deeper soundings were nevertheless made, showing in the centre of the Maldive group a comparatively shallow (200 fathoms) table on which the majority of the atolls and banks have arisen. A subsequent expedition by that renowned American investigator Professor Alexander Agassiz has further elucidated the greater depths, and its full report, when published, will probably be found to give a very complete idea of the whole topography of the Maldive Archipelago.

While a fair knowledge has now been attained of the conditions and life on the floor of the deep sea, there has unfortunately been little work done in *oceanic* areas on the shallower bottom down to 500 fathoms. The evidence from the Maldive group shows how peculiarly interesting would be such a knowledge of the conditions between 50 and 200 fathoms. Indeed, an expedition undertaken mainly for this object would certainly do more to elucidate the probable and possible methods of the formation of coral reefs than any other mode of investigation. Further, such an expedition would undoubtedly throw an immense flood of light on the bathymetrical distribution of animals and plants. It would also make possible a proper examination into the questions relating to the geographical distribution of marine animals and plants, a subject at present untouched,

[1] See also 'The Origin of Coral Reefs as shown by the Maldives,' by J. Stanley Gardiner, *Amer. Journ. Sci.*, vol. xvi., Sept. 1903, pp. 203–213.

[2] These forms depend mainly on their commensal algæ for their nutrition, but the existence of a perfectly distinct coral fauna living at intermediate depths, having its maximum luxuriance at about 40 fathoms, and not depending on commensal algæ, was discovered.

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but one which, I venture to predict, will throw more light than even that of land animals on the past changes of land and sea on the earth. The further investigation of the interesting question of the formation of coral reefs in my opinion calls for such an expedition. From several areas might be expected important results on which a host of questions at present depend. A well-equipped steamer would be essential, but the equipment of such an expedition is beyond private enterprise.[1]

The publications of the 'Results of the Funafuti Expeditions' and of Professor Agassiz's Maldive expedition may shortly be expected. The time for such an investigation as I have indicated above will not perhaps be ripe for one or two years, but I venture to hope that the question will be considered by the Committee.

The Committee ask for reappointment without a grant.

Investigations in the Laboratory of the Marine Biological Association of the West of Scotland at Millport.—Report of the Committee, consisting of Sir JOHN MURRAY (*Chairman*), Dr. J. F. GEMMILL (*Secretary*), Professors BOWER, COSSAR EWART, W. A. HERDMAN, *and* M. LAURIE, *and* Messrs. ALEX. SOMERVILLE *and* J. A. TODD.

Of the grant of 25*l.* given in 1901 the greater part was expended during 1902 in enabling Mr. Alexander Patience to investigate the Crustacea of the Clyde sea area, and Dr. Jas. Rankin, B.Sc., to investigate the Compound Ascidians of the same area. Reports by these workers were submitted in 1902, that of Mr. Patience being an interim one. Mr. Patience has now presented his report to the Committee, which is as follows :—

Report on the Crustacea collected during the Dredging Cruise of the Millport Marine Biological Association's Steamer 'Mermaid' since May 1902. *By* ALEXANDER PATIENCE.

Investigations were carried out, on various dates since May 1902, in all the Northern Clyde Lochs, in Kilbrennan Sound, in the vicinity of the Great and Little Cumbraes, and from the Little Cumbrae to Ailsa Craig. In all, dredgings were taken from 140 stations. The depths ranged from 5 to 107 fathoms. This is the greatest depth within the Clyde sea-area, and is found in Lower Loch Fyne, off Skate Island.

The chief object of my investigations was to study the distribution of the *Malacostraca* within the Clyde sea-area.

Apart from the new species discovered and the new records made, the distribution of many of the *Malacostracan* species has been extended, especially among the *Schizopoda*, since the publication of Dr. Scott's list in 1901.[2] In this short report I cannot deal with this part of my investigations, but hope to publish, at an early date, an extended paper giving details.

[1] I estimate the cost at about 12,000*l.* for a well-equipped expedition.

[2] *B.A. for Adv. of Science, Glasgow*, 1901, 'Fauna, Flora, and Geology of Clyde Sea-area,' p. 328.

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As mentioned in my interim report, two new species were discovered, viz. :—

Pleurocrypta Patiencei, Scott. *P. Clutha*, Scott.

They have been described by Dr. Thomas Scott, F.L.S., of H.M. Fishery Board, in a paper contributed to the 'Ann. Mag. of Natural History.'

I have reason to believe that a *Sacculina* which I discovered on *Munida rugosa*, Fabr., as also one on *Galathea intermedia*, Lillj., and a *Peltogaster* on *Anapagurus lævis*, Thomp., are new to science. I am waiting, however, for further material to establish this fact.

The following species which I have discovered are new to the Clyde sea-area, viz. :—

Decapoda.

Ebalia Costæ, Heller.
E. Costæ, Heller, var. *granulosa*, Milne-Edw.

I am indebted to Dr. Norman, F.R.S., for identifying the above. I have verified Landsborough Martin's record of the occurrence in Clyde waters of *E. Cranchii*, Leach, which was held as doubtful by Dr. J. R. Henderson.[1]

Xantho hydrophilus, Herbst., var. *tuberculata*, Couch.

I have established the occurrence, at the greatest depth (107 fathoms), within the Clyde sea-area, of *Pandalus Montagui*, Leach. Records of its occurrence in depths of over 70 fathoms in British waters have hitherto been regarded with doubt.[2]

Schizopoda.

Macropus Slabberi (Van Beneden). *Pseudomma roseum*, G. O. Sars.

I have contributed two papers to the Glasgow Natural History Society of Glasgow dealing with the occurrence of the two above-named *Schizopods* within the Clyde sea-area.

Isopoda.

Idothea neglecta, G. O. Sars. *I. viridis* (Slabber).

I am of opinion that these two species have been confounded by previous observers in the Clyde with *I. baltica* (Pallas).

I submitted them to Dr. Scott, who agrees with my identification of them.

Eurydice spinigera, H. J. Hansen. *Cymodoce truncata*, Leach.

I believe this species, as well as *C. emarginata*, Leach, were recorded by the late Dr. Robertson, Millport, but have been inadvertently omitted from Dr. Scott's list.

Pleurocrypta longibranchiata (B. & W.) on *Galathea dispersa*, Bate; and on *G. squamifera*, Leach.

[1] *Proc. Nat. Hist. Soc. Glas.* (n.s.) vol. i. p. 353.
[2] Calman, *Ann. Mag. Nat. Hist.*, vol. iii. 7th series, pp. 27, 39.

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The following species have been found on new hosts, viz.:—

Bopyroides sarsi, Bonnier, on *Spirontocaris securifrons*, Norman.
Pseudione crenulata, G. O. Sars, on *Galathea dispersa*, Bate.
P. Hyndmanni (B. & W.) on *Anapagurus lævis* (Thomp.)
Athelges paguri (Rathke) on *A. lævis*, and on *Eupagurus Prideauxii* (Leach).

Another species, *A. Prideauxii*, Giard and Bonnier, has been found on the last-named species of decapod; but Stebbing says[1] that 'the adult female retains a rudimentary fifth pair of appendages on the pleon which are transitory on the former'—*i.e.* on *A. paguri*. In my specimens, however, which seem to be fully matured, there are only *four* pairs, and the form of the two plates of which each appendage consists is exactly the same as in *A. paguri*. I have shown these specimens to Dr. Scott, and he has referred them to *A. paguri*, and on this point I fully agree with him.

Phryxus abdominalis (Kr.) on *Spirontocaris pusiola* (Kr.); *S. Cranchii*, Leach; and *S. Gaimardii* (Milne-Edw.)

I have not completed my survey of the *Cumacea* and *Amphipoda*, but hope to publish the results at an early date.

The Committee ask for a renewal of the grant of 25*l.* given in 1901, to enable Mr. R. T. Leiper to investigate the Acœlous Turbellarians of the Millport area and to enable Mr. D. C. McIntosh, M.A., to work at Variation in *Ophiocoma granulata* (O. F. Müller) and other Echinoderms, and to enable Mr. Alex. Patience to continue his investigations on the Crustacea of the Clyde sea-area.

The Committee ask to be reappointed, with the addition of Professors J. Arthur Thomson and J. Graham Kerr.

The Micro-chemistry of Cells.—Report of the Committee, consisting of Professor E. A. Schäfer (*Chairman*), Professor A. B. Macallum (*Secretary*), Professor E. Ray Lankester, Professor W. D. Halliburton, Dr. G. C. Bourne, *and* Professor J. J. Mackenzie. (*Drawn up by the Secretary.*)

The Committee report that the work of detecting and localising calcium and potassium in the vegetable cell, which was begun in 1901–2, was continued, and that in regard to potassium results of importance were obtained which may have a bearing also on the interpretation of the rôle of sodium, magnesium, and calcium in the living cell, both animal and vegetable.

The Localisation of Potassium in the living Cell.—It was found possible to precipitate potassium as the hexanitrite of potassium and cobalt, which occurs in minute octahedral crystals if the potassium salt is present in considerable quantities in the living protoplasm, but in a diffuse form if it obtain only in traces. The reagent used to effect this is the hexanitrite of cobalt and sodium, $Na_3CO(NO_2)_6$, and when dissolved in a diluted solution of

[1] *A History of Crustacea*, Int. Sci. Series, vol. 74, p. 409.

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acetic acid it gives an instantaneous precipitate of the hexanitrite of cobalt and potassium, $K_3CO(NO_2)_6$, carrying down with it a certain quantity of the precipitant, $Na_3CO(NO_2)_6$. So completely is the potassium removed from solution that the reagent is found to be of service [1] as a means of separating the element from the other alkalies and the alkaline earths in the quantitative estimation of potassium. The precipitate is but very slightly soluble in water, which may therefore be used to remove the excess of the precipitant, after which the precipitate may be washed with a solution of sodium nitrite to which acetic acid has been added, or with a solution of sodium acetate. In either of these solutions the precipitate is practically insoluble, and is thereby freed from traces of the corresponding ammonium compound, $CO(NH_3)_3(NO_2)_6$, which is much more soluble than the potassium compound.

This reaction does not precipitate the amido acids, glycin, leucin, taurin tyrosin, sarcosin, aspartic acid, or glutamic acid, nor does it precipitate urea, carbamic acid, asparagin. These therefore do not complicate the reaction, and the only compounds in living protoplasm which, in addition to those of potassium and ammonia, precipitate with the reagent are creatin and oxalic acid. The former separates out from solution only slowly, and not at all if solution is very dilute. As it does not occur in the vegetable cell, and is unknown in the tissues of invertebrates, it cannot confuse the determination of the presence of potassium. The distribution of oxalic acid and its salts is so limited that they cannot interfere with the success of the reagent in localising potassium in the cell.

The hexanitrite of cobalt and potassium is brownish yellow, and, therefore, except when it is abundant, not readily recognisable directly. It is brought into view by treating the preparation with ammonium sulphide, which reveals the presence of the potassium through the black sulphide of cobalt, CoS. If at the same time it is mounted on the slide in dilute glycerine, to which a trace of ammonium sulphide is added, it will keep unimpaired for a few weeks.

Some of the results of the investigation with this reagent are especially interesting in that they directly negative the generally accepted views as to the distribution of the salts of the alkalies in the cell.

1. As a rule the nucleus is free from potassium, even when the cytoplasm contains it in abundance (the intestinal epithelium of insecta and crustacea, the erythrocytes of amphibia). In algæ the nucleus of the healthy cell never contains potassium, and even in karyokinesis the chromatic filaments are free from it, however abundant it may be in the cytoplasm. In such non-nucleated forms as the cyanophyceæ the 'central body,' which is regarded by cytologists generally as the homologue of the nucleus of higher forms, is also absolutely free from potassium, although it may occur in abundance in the peripheral zone, and particularly in the so-called 'red granules' of Bütschli.

2. The salts of potassium when abundant in the cytoplasm are not uniformly diffused through the latter. In the vegetable cell as a rule only a minute quantity is so diffused, while the rest is localised apparently as precipitates in portions of the protoplasm which serve as inert structures, and these are situated adjacent to the cell membrane (algæ). In this respect the salts of potassium are disposed of like those of iron when the

[1] Van Leent, *Zeit. für anal. Chemie*, vol. xl. 1901, p. 567; also Autenrieth and Bernheim, *Zeit. für physiol. Chemie*, vol. xxxvii. 1902, p. 29.

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latter is abundant in a cell. The quantity of potassium required by protoplasm is very small, as shown by the feebleness of the reaction obtained in the growing points of vegetable organisms. In old as compared with young cells the quantity is great, but the excess is stored away in the inert form, and is apparently due to the protoplasm precipitating it from the water constantly diffusing into the cell. This may explain the high proportion of potassium found in the cells of vegetable forms, and it seems to indicate that more is present than is required. Further, the varying amounts in different vegetable forms may be accounted for as caused by variation in the flow of the sap, in the transpiration currents, and perhaps also in the dissolving powers of the secretions of the root-hairs.

When the potassium salt is stored away in the inert form it is, unlike the inorganic iron, still subject to solution and redistribution by the protoplasm, as is illustrated in the case of the spores of equisetum, the potassium of which is in by far the greater part transferred on division to that daughter cell which gives origin to the primary rhizoid. A similar control over the precipitated potassium is found in the formation of the zygospores of spirogyra.

3. In the cytoplasm of the animal cell the potassium as a rule is much less abundant, and when this element predominates in the medium from which protophyta derive their abundance of potassium the accompanying animal forms contain only traces of it (vorticella), and then chiefly in the form of small localised precipitates. The unicellular animal organism appears to be capable of rejecting the potassium even when it comes in the food masses. On the other hand the cytoplasm of the epithelial cells in the intestine and the excretory organs of vertebrates and invertebrates is deeply impregnated with potassium salts which appear to be in the process of excretion.

4. In striated muscle fibre the potassium is limited wholly to the doubly refractive material in the dim band (frog). This is significant seeing that the potassium greatly exceeds the sodium in voluntary muscle fibre, the proportion in frog's muscle being 557 : 100. The element is found also in the doubly refractive material of the fibres in the wing muscles of insects and in the muscles of the lobster. Here there can be no reason for doubting the nature of the reaction, since creatin does not occur in the tissues of invertebrates.

It is proposed to continue the investigation of the distribution of potassium in the cell, and to make an extensive examination for this purpose of a large number of animal and vegetable forms.

Terrestrial Surface Waves.—Report of the Committee, consisting of Dr. J. SCOTT KELTIE (*Chairman*), Dr. VAUGHAN CORNISH (*Secretary*), Colonel F. BAILEY, Mr. E. A. FLOYER, Professor J. MILNE, *and* Mr. W. H. WHEELER. (*Drawn up by* Dr. VAUGHAN CORNISH.)

[PLATE X.]

Variability of the Severn Bore.

THIS phenomenon is subject to apparently capricious variations in addition to that which depends upon the varying amplitude of the tide. Visiting Newnham-on-Severn on the occasion of one of the highest tides

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of an early autumn I found that there was practically no bore, although in springtime I had seen a good one with a smaller tide. The fishermen opined that the sands between Awre and Frampton, a few miles down the river, had shifted in some way, which would be found to account for the failure of the bore at Newnham. Accordingly at the next succeeding tide I took up a post of observation at Hock Crib, where I could command a view over the extensive sands in the broad straight stretch towards Severn Bridge, which constitutes the commencement of the proper estuary, as well as of the last bend of the winding channel of the river proper looking towards Newnham. The main stream of the river had established itself in a channel somewhat near the right bank, and up this the 'first of the flood' came with a good 'head' to it, the bore appearing as a crested breaking wave stretching quite across the low-tide channel. It thus continued until it reached a point close to Hock Cliff, at the head of another channel which skirts the concave left bank, passing Frampton. From the position now reached by the incoming flood, water now poured *back* into this channel, the further advance of the tide up stream being stopped. Presently the back-flowing stream met another coming up the Frampton Channel, and the turbulent waters then began to spread over the large expanse of sand intervening between the two channels. Not until these were nearly covered did any perceptible rise of tide make its way up the river channel towards Newnham. The total rise of tide is unaffected by this course of events, but the 'head' which the flood had gathered is lost and the bore is spoilt. It was pointed out in a paper on sand waves in tidal estuaries that the flood tide tends to follow the chords of the arcs made by the sinuosities of an ebbing current. According to the information collected by the late Mr. Frank Buckland, the Severn in a wet season tends to collect in the Frampton Channel, and in a dry season in the Awre Channel.

In the estuaries of the Mawddach, Dovey, &c., dealt with in 'Geogr. Journ.' August 1901, the last of the ebb and the first of the flood respectively had settled into separate channels and there was no bore, but a circulation of the tidal waters.

That the continued action of the flood tide upon the sands minimises the bore which it at first produces is further shown by the observation of Mr. D. J. Wintle, of Newnham-on-Severn, who reports that 'the best heads are two tides previous to the highest tide of the moon—say for four tides before the highest of the moon. The very next tide after the highest tide may run within a few inches of the same flood-mark, but will have a comparatively poor head and lack crispness.'

On the Size of Waves as related to the Rate of Advance of a Cyclone.

The greatest waves will be developed in that part of the cyclone in which the direction of the wind coincides with the direction of advance of the cyclone, and I wish to call attention to the fact that, along this line of action, of all the waves which the velocity of the wind is capable of increasing, that length will enjoy superior opportunities for growth *whose group velocity is equal to the rate of advance of the cyclone*, the storm either outrunning or lagging behind the transmission of energy in waves of any other length. The velocity of the group in deep water is half the velocity of the individual waves.

It was pointed out in the last report that the period of the longest

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recorded swells corresponds to a wave velocity about equal to that of the greatest recorded hourly velocity of wind (the velocity of the dominant wave in storms being much lower).

It may be added that no records of swells have been met with having periods approaching those appropriate to a deep-sea velocity equal to that attained during the gusts of a storm.

Mathematical investigations have pointed to the tendency of wind finally to produce steep waves of velocity equal, or almost equal, to that of the wind. When, however, we come to compare the observed velocities of wind, the observed dimensions of cyclonic storms, and the lengths of waves of velocity equal, or nearly equal, to that of the strongest winds, we find that we rapidly approach a condition of things when the stretch of water subject at any one time to such wind is only a small multiple of the wave length; a condition in which steep waves could not be maintained.

On Regular Undulations produced in a Road by the Use of Sledges.

An investigation on this subject was completed after last year's report had been sent in, but was made the subject of a paper to Section G (Belfast meeting). These undulations have been observed both in snow and in ordinary road material. Those in snow are a familiar feature in Canada and are termed cahots. An illustration is here given of 'cahots' in ordinary road material as observed upon the road to a slate quarry at Coniston, Lancs. (Plate X.).

The chief result of the investigation may be summarised thus: when the detritus consolidates readily under pressure, undulations arise spontaneously by the action of a steadily moving sledge when furrowing a homogeneous road. The wedge of detritus travelling in front of the prow of the sledge becomes compacted, the sledge surmounts it (rolling like a wheel), and the detritus remains behind as an excrescence incorporated with the road. At the same time the sledge pitches, furrowing the road more deeply and accumulating detritus in front, which it finally surmounts with the rolling movement which assists to compress and bind the material, building up the next crest.

Wave Phenomena of the Niagara.

I have visited Niagara Falls, N.Y., with a view to reporting upon some of the characters of *the waves of rivers* which I judged would be seen in full development in the Rapids below the Falls. Three weeks' work showed that the choice of locality for this study was a good one, and afforded opportunity also for the study of phenomena of a kindred character in the falls themselves and in the whirlpool. Indeed, it is to the periodic and pulsative movements that much of the distinctive character and interest of the Falls and Rapids are due.

There has not yet been sufficient time to work up the results of these observations for publication.

As an indication of the character of the phenomena observed at Niagara it may, however, be stated that in the tremendous current of the Whirlpool Rapids (depth about 50 feet) there is, in addition to the usual stationary waves of rivers, a remarkable development of visible travelling waves, giving rise to many complex and beautiful results and contributing

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Illustrating the Report on Terrestrial Surface Waves

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to the formation of the enormous *leaping waves* which are one of the most awful exhibitions of the conflict of waters which the world affords. What is here termed the 'leaping wave' is a variety of wave almost as distinctive as the 'breaker' or 'the swell.'

Women's Labour.—Third and Final Report of the Committee, consisting of Mr. E. W. BRABROOK (*Chairman*), Mr. A. L. BOWLEY (*Secretary*), Miss A. M. ANDERSON, Miss BLACKBURN, Mr. C. BOOTH, Professor S. J. CHAPMAN, Miss C. E. COLLET, Professor F. Y. EDGEWORTH, Mrs. J. R. MACDONALD, Mr. L. L. PRICE, Professor W. SMART, Dr. G. ADAM SMITH, *and* Mrs. H. J. TENNANT, *appointed to investigate the Economic Effect of Legislation regulating Women's Labour.* (*Drawn up by the Secretary.*)

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THE Committee have associated with them in their work Miss Heather-Bigg and Mrs. Bosanquet. They desire to express their deep regret at the death of Miss Helen Blackburn, who was a regular and valued attendant at their meetings.

Miss Collet wishes it to be understood that she is unable from her official position to express any opinions on the subject under investigation. Her examination and criticism of the evidence submitted has, however, been of the greatest value to the Committee.

Dr. C. Booth, Professor W. Smart, and Dr. G. Adam Smith have been unable to attend the meetings of the Committee at which this report was prepared and their conclusions on the matters in question have not been communicated to the Committee.

The Committee have obtained further information from investigators, the essential parts of which are included in their report or its appendices. They consider that, though it has not been practicable to cover the whole field of their inquiry, they have practically exhausted the means of investigation open to them and have obtained sufficient information, on the more important points on which evidence is procurable, to justify them in arriving at certain conclusions and closing their work.

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The following reports have been received by the Committee, including those summarised last year :—

Trade or District.	*Investigator.*
[1] Cotton in *Lancashire*[2]	Professor S. J. Chapman.
[1] West Riding of *Yorkshire*	Mr. A. L. Bowley.
[1] Certain Industries in *Birmingham*	Miss B. L. Hutchins.
[1] *Boots* and Shoes in and near Bristol	Mr. G. H. Wood.
[1] *Leicester*, Northampton, and neighbourhood	Mr. R. Halstead.
[1] Certain Industries in *Canning Town* and Isle of Dogs	Miss Hadley.
Nottingham	A special local Committee.
Sheffield	Mr. G. I. Lloyd.
Kidderminster	Mr. G. H. Wood.
Coventry	,,
Derby	,,
Tinplate Manufacture	,,
The *Potteries*	Miss Thornewill.
Paper-making near London	Miss B. L. Hutchins.
Some *South London* Industries	,,
Liverpool	Miss A. Harrison (Mrs. F. H. Spencer).
Printing and *Bookbinding*	Committee organised by Women's Industrial Council, London.[3]
Glasgow and South of Scotland	Miss Irwin.
Tailoring in London	Committee of the Women's Industrial Council, London.
London Industries and West London *Laundries*	Mrs. Bosanquet.
Laundries (*Appendix II.*)	Miss A. M. Anderson.

The Committee have also received memoranda on the Statistics of Dangerous Trades from Mr. Wood, and on general statistics of Women's Employment from Miss Collet.

Extensive use has been made of the reports of the Chief Inspector of Factories, which have been issued at half-yearly or yearly intervals since 1834.[4]

In all cases the investigators were supplied with directions respecting the exact questions on which the Committee desired information, and their work has been subjected to all practicable tests before being used as evidence on which the Committee could come to a decision; but, as stated last year, it must be understood that the Committee do not necessarily assent to the opinions given under the names of their contributors.

It will be seen that reports have been received with regard to most of the important industries, and most of the important towns and districts in England and Wales, in which large numbers of women, affected by the Factory Acts, are employed; but it has not been found practicable to institute inquiries in Norwich, Aberdeen, Dundee, or Belfast, or to investigate industries in which there is much home-work, or in which much work is given out from the larger factories or workshops to be done elsewhere (principally the ready-made clothing, tailoring, and other wearing-apparel industries) with the thoroughness which the Committee

[1] Already published in the Belfast Report, pp. 287–306.

[2] These reports are referred to in the sequel by the *italicised* words.

[3] The notes kindly communicated by this Committee were prepared for their book, *Women in the Printing Trades*, about to be issued.

[4] Reference to these is made thus: *Factory Inspector's Report*, 1894, the date given being that to which the report relates

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would have desired. On the other hand, much information as to these towns and industries has been found in the reports of the Chief Factory Inspectors. The difficulty of investigation in industries of this class lies, in a great part, in the general ignorance of the facts by the only persons who are in a position to know them.

The Committee have interpreted the subject referred to them as applying only to that part of legislation which discriminates between men and women; they do not, therefore, report on the effect of laws relating to the prevention of accidents, to sanitation, and to special regulations for dangerous trades, except in the few cases where they affect women differently from men, or where women are a great majority of the persons affected. The main regulations with which the Committee are concerned are therefore those which define the hours of employment. In this final Report they confine themselves to Great Britain.[1]

These regulations are of great complexity, and have frequently been extended and amended. The greater part of those now in force is contained in the Factory and Workshop Act of 1901. Their history, change, and development can be most easily studied in 'The Factory System and the Factory Acts,' by R. W. Cooke Taylor, 1894; 'The Factory Acts,' by A. Redgrave, 1895; 'The Law relating to Factories and Workshops,' by M. Abraham and A. Ll. Davies, 1896; 'The Law of Factories and Workshops,' by A. H. Ruegg and L. Mossop, 1901, and 'A History of Factory Legislation,' by B. L. Hutchins and A. Harrison, 1903, which last contains a nearly complete bibliography on the subject, as far as Great Britain is concerned.

It will be convenient, however, to give a very condensed summary of the principal regulations.

In *textile* factories the hours of women were limited in 1850 to a period of 12 hours less 1½ hour for meal-times on the first 5 working days, and to 7½ hours on Saturday, amounting to 60 hours per week. In 1874, ½ hour was cut off each of the 5 days and 1 hour off Saturday, making the total hours per week 56½; on January 1, 1902, another hour was cut off Saturday, making the total hours 55½.

Regulations of women's hours, resulting by 1878 in a uniform 60 hours' week as legal maximum (viz. not more than 10½ hours on 5 days, to be taken in the 12 hours beginning either at 6 or 7 or 8 A.M., and 7½ hours on the sixth day), were extended in 1864, 1867, 1870, and 1878 successively, to all *non-textile* factories in which mechanical power is used, and *workshops* where manual labour is employed in making, repairing, or altering any article for sale. In addition to these hours, overtime is allowed under certain restrictions in certain industries (notably bookbinding and the making of wearing apparel), where there is a seasonal or sudden occasional pressure, or where the materials are liable to spoil, *e.g.*, fruit-preserving and fish-curing; before 1895 overtime might be worked for forty-eight evenings in the year, 2 hours an evening less ½ hour for meals, not more than five evenings being in any one week; in 1895 the number of evenings permissible was reduced to thirty, not more than three in one week.

As each industry came under the Act, night work by women in it was prohibited, except in the case of laundries.[2]

[1] In their second Report (Belfast, 1902) summaries of similar legislation in several European countries were given.

[2] See the last part of Appendix I. below.

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There are many modifications to suit special circumstances, and some important exemptions.

For the purpose of tabulating the information gathered, it is convenient to consider the effect of these laws. I. On the hours worked by women; (*a*) the total weekly number; (*b*) the distribution through the day, week, and year. II. On the hours worked by other persons. III. On factories or workshops of different sizes, and on the prevalence of out-work. IV. On the employment of women in particular processes, and on the general demand for their labour, and on the re-arrangement of production by employment of other classes of labour, or the introduction of machinery. V. The effect on women's rates of wages and total earnings. VI. On the efficiency of women as industrial agents. VII. On the efficiency of productive processes in general. These subjects are dealt with in the following sections :—[1]

Section I.—*Effect on the Hours worked by Women.*

(a) *The Total Weekly Number.*

In the great majority of cases the hours in *textile* trades were reduced from 60 to 56½ in 1874–75, in consequence of the Act (*Lancs., Yorks., Kidderminster*); in some cases the hours were only 59 before 1874 (*Yorks.*). Though in many cases the hours were reduced to 55½ hours or less before 1902, yet in the majority the work on Saturday was curtailed in consequence of the Act of 1901. The hours are increased illegally in many places in Lancashire, and some in Yorkshire, by 'cribbing time,' that is, working a few minutes before and after the legal hours; an hour or more a week can easily be added in this way.[2]

In *non-textile* trades in general the Acts have had comparatively little to do directly with fixing the normal week's work. In many industries the hours were under 60 before they were regulated by the Acts.[3]

In more recent years the hours in industries regulated by the Acts have often been well under the legal maximum; while in men's industries influenced by trades unions the hours are very rarely so many as 60. Examples of regulated industries where the normal weekly hours are below the legal maximum are the trades of Sheffield, Nottingham, Coventry, Derby, the boot and shoe trades of Bristol and Leeds, the wholesale clothing trade of Leeds, most of the Liverpool trades, and the list might easily be extended. There are other cases where the hours used to exceed 60 per week, and are still in times of ordinary full work up to the maximum. Thus, match-making in Liverpool used to extend over very long hours, but now a firm reports that they work 10 hours a day, and do not take 10½, only because it would not be worth while to have the necessary additional meal-time.[4] The hours in rope-walks in Liverpool were long and irregular before the 1867 Act. In the London tailoring workshops the hours are up to the limit, though below it in the larger factories. In some of the industries dealt with below, where over-

[1] Reference to investigators' reports are italicised, thus: *Lancashire.*

[2] *Yorkshire; Factory Inspector's Report*, 1897, p. 106; 1899, p. 20; 1900, p. 311; 1902, p. 119.

[3] *Factory and Workshop Commission*, 1876; *Factory Inspector's Report*, October, 1869, p. 37; and October, 1879, p. 20.

[4] A woman must not be employed continuously more than 5 hours without an interval of at least ½ hour.

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time is allowed or desired, the full legal hours are often worked in busy seasons, though in recurring times of slackness they are not reached. As the administration of the Acts has become effective in the smaller workshops of the large towns, the hours have frequently been brought down to reasonable limits, *e.g.* in London, Glasgow, and Birmingham.

It is not to be assumed, however, that the existence of the regulations has no influence in such cases. It is practically certain that the textile factories would often exceed the limit if it were allowed (*Yorks.*); *e.g.* the *Derby* elastic web industry feels the prohibition of overtime. In non-textile factories and workshops, especially in the clothing trades, and printers' folding, the interval between the customary weekly period and the legal maximum is often filled in (and spoken of commonly as 'overtime'); frequent demands are made on the additional hours allowed thirty times (formerly forty-eight) annually by the Legislature, while even this limit is not infrequently passed by firms who hope to escape detection.

In the industries connected with printing (especially folding) throughout the kingdom, in many cases as much overtime is worked as is possible, and employers find it difficult to meet periodical pressure connected with the despatch of magazines &c. with the amount allowed. Ready-made clothing factories (*e.g.* in Leeds) use a great part of the extra evenings allowed them, and these and smaller firms in Leeds, Glasgow, Liverpool, and London give out work (sometimes illegally) when they are pressed; but, in the main, the thirty occasions are found sufficient. In South London a biscuit firm finds the want of elasticity troublesome; and so does a Bristol sweets manufacturer. In Nottingham 'in the lace, hosiery, and embroidery trades, many employers desire a measure of liberty in the use of overtime to meet exceptional periods of stress to which the lace trade is specially liable. . . . According to testimony of workers in both lace and hosiery trades, the Acts are very often ignored when inconvenient. Many employers agree with this statement' (*Nottingham*). The manager of a large watch-factory near Liverpool, stated in 1902 that his firm was greatly inconvenienced by having to keep within the legal hours in December, when special pressure occurs. In many other isolated cases some firms in an industry complain of want of overtime, while others have arranged (see below) to do without it.

The abolition of night-work for women has been effective in the Welsh tinplate manufacture, in paper-making, and to a great extent in printers' folding; but cases are recorded[1] of folding being done, legally, by women in separate premises at night. A great diminution of night-work in laundries has occurred as an indirect consequence of the Act of 1895 (*App. II.*).

(b) *The Distribution of Work through the Day, Week, or Year.*

A very important, perhaps from the economic point of view the most important, effect of legislation has been to spread the period of work more uniformly through the week, month, and year than had been the case before regulation. It would hardly be an exaggeration to say that there is no trade or district to which these laws apply where this process has not taken place.

It is convenient at this point to analyse the possible effects of the diminution of *overtime* in regulated factories and workshops.

[1] E.g., *Factory Inspector's Report*, 1902, p. 149.

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1. The same amount of time may be worked outside the factory.
2. The number of employees or quantity of machinery working ordinary time may be increased either occasionally or permanently.
3. Employees not affected by the regulations may work overtime at work usually done by protected persons.
4. The order may be given to other firms or workers (α) at home, less busy; (β) at home, less regulated; or (γ) abroad.
5. Work may be equalised through the week, month, or year (α) by the employees giving up the habit of holiday-making at the beginning of the week, (β) by pressure being put on customers to place orders earlier, (γ) by working to stock, (δ) by careful management.
6. Machinery may be invented to do the work.
7. The same employees may produce the same output in the shorter time.
8. The work may be left undone.

A great part of the above analysis applies to diminution of *normal* time, but this has less important effects in this connection than *overtime*, and is dealt with under other headings.

We have among our information instances of every case except 8; but evidence for 4 (α) and (γ) is unreliable.

3 and 6 will be dealt with below in Section IV., and 7 in Section V.

1. In some cases work is given to out-workers not employed in the workshop (London Printing, in *Factory Commission*, 1876); some folding was done thus in 1899 (*Printing and Bookbinding*); out-work increased in the Stockport clothing trade by the 1895 reduction.[1] In other cases work is given to employees to take home nominally to their relations (*London*, ready-made clothing),[2] to employees to do themselves after hours (illegally) (*Sheffield*, electroplate; ready-made clothing in various places).

2. Extra workers (frequently married women formerly employed) may be called in.

This is frequent in printing and kindred trades, in London and Nottingham at any rate, where job-hands are called in on emergency, sometimes regularly month by month. To those who have home duties which prevent them from taking continuous work, this occasional employment, practically called into existence by the Acts (*Printing and Bookbinding*), is attractive. The expense of setting up extra machinery only to be used occasionally is wasteful, and the additional rent for the space necessitated for this or for extra hands involved is an important consideration in the large towns where the pressure most frequently occurs (*Liverpool*, confectionery). It is easily seen that an indirect effect of limiting hours is, through the pressure of rent, to drive firms from crowded into less congested districts.

If the number permanently engaged were increased, more might be brought into the industry than can get sufficient employment (watch-making, near *Liverpool*; Dundee, *bookbinding*).[3]

In some cases workers go from trade to trade in their successive seasons, in others they work only at the busy season; in the case of fish-

[1] *Factory Inspector's Report*, 1896, p. 38.
[2] *Ibid.*, 1901, p. 145.
[3] *Ibid.*, 1896, pp. 39.

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curing they follow the fish round the coast; but these cases are not connected with the regulations.

4. Employers occasionally complain that work has to be refused (*Yorks.*, silk), but often (α) the order can be placed with other firms in the same district. In Yorkshire the system of commission weaving enables the various firms to put out the work they cannot cope with. (β) Tailoring and other clothing is sometimes taken by small employers or home-workers, who escape regulation.

5. (α) In watch-making and the ribbon trade at Coventry, and in the Potteries, the practice of not beginning work on Monday and working at high pressure at the end of the week is diminished; collection for laundries has, in some cases, been re-arranged; but often this should be ascribed primarily to the invention of machinery.

(β) The tendency to put off giving orders to the last moment is easily checked when the customer can be met with a universal legal prohibition. In laundries the work has been regularised.[1]

(γ) In modern industry, working to stock is risky, and not much improvement can be expected in this respect.

(δ) Several instances (*Liverpool*, jute and dyeing; *South London*, tin-plate; Bristol, *boots*)[2] are given where forethought and arrangement have diminished pressure. The restriction puts a premium on good management.

In *Sheffield* we are told: 'There has been a noticeable diminution in the amount of overtime worked in busy seasons for which the Acts have been largely responsible; regularity of work has also been encouraged.'

It will be seen that the large group of industries which have met the restriction by methods 4 (α) or (δ) or 5 have benefited greatly without any drawback; that 1 and 4 (β) will be of decreasing importance as effective regulation spreads; that 4 (γ) is hypothetical and not necessarily injurious; that 2 may, according to complex circumstances, assist or hinder the flow of labour into its most efficient channels.

The difficulty which arises when it is necessary to perform one process immediately after another has been completed by a different class of workers is being met by allowing work to commence and finish at different times in different parts of the same factory.[3]

It is the constantly reiterated opinion of the individual factory inspectors[4] that overtime is in very many cases as unnecessary as it is injurious.[5]

Important light is thrown on the abuses which elasticity of regulation may allow by the description of the conditions of the jam manufacture given in *Factory Inspector's Report*, 1898, pp. 173 *seq.*

[1] See in Factory Commission, 1876, evidence of Mr. Bell, bookbinder (Q. 2943); *Factory Inspector's Report*, 1894, p. 191; 1902, p. 29; and 1892, p. 89, for an instance at an earlier date.

[2] *Factory Inspector's Report*, 1894, p. 11; 1896, pp. 39, 40.

[3] *Ibid.*, 1900, p. 218.

[4] *Ibid.*, 1892, p. 88; 1893, pp. 16 and 299; 1894, pp. 12, 20, 23, 28, 191; 1895 pp. 13, 117; 1898, p. 66; 1900, pp. 248, 278; 1902, p. 29.

[5] For the contrary opinion see *Factory Inspector's Report*, 1897, p. 68, and for both opinions see *Labour Commission*, Digest Group, C., vol. i., p. 39, Factory Inspector's evidence.

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SECTION II.—*Influence of Restriction of Women's Hours on the Hours worked by other persons.*

In the cotton industry of Lancashire there seems no doubt that the hours of non-protected persons are determined almost entirely by those of protected persons; but it is not possible to say to what extent they have been influenced specially by the restrictions on the work of adult women, for the work of young persons and children is also of the greatest importance (*Lancs.*).

In the wool industry of Yorkshire a great number of the men work the hours allotted to the women, and it is common for the engines to run only during those hours; on the other hand, several instances are given where the men's hours are quite different from the women's, and hardly influenced by them; while in a third group are found cases where the men continue women's work at hours prohibited to women (*Yorks.*).

In the carpet industry of *Kidderminster* the hours of work were brought down to 56½ in 1875, and 55½ in 1902, in consequence of the Acts. 'As the work of the men is mostly dependent on protected assistants, their hours would probably have been reduced even if the rules of the Power Loom Weavers' Association had not necessitated that the weavers, at least, should reduce their hours when those of the women &c. were reduced.' The Acts also hinder men working overtime, except in rare cases where it is worth while to pay men for doing women's work.

In the Potteries women's work is so involved with men's that the greater regularity of the former necessitates the same for the latter; and a similar remark applies to those men who, through custom or necessity of processes, work the same hours as women, in those industries whose increasing regularity was pointed out in the last Section.

It is open to question, however, whether without the Acts the hours for men might not be shorter; for in the majority of trades, where the hours are decided by agreements with trade unions, the hours are below the legal maximum in regulated trades; and it is possible that in the textile industries the men, if not aided or forestalled by the Legislature, would by this time have obtained a 54 hours' week in Lancashire and Yorkshire. This consideration makes it impossible to decide to what extent the shortening of hours is to be attributed to the Acts, and to what extent to the general tendency to amelioration of conditions. From the evidence already given, however, it seems in the highest degree probable that the hours would have been longer and much less regular in most factories and workshops affected, but for legislation.

SECTION III.—*Effect on Factories and Workshops of different sizes, and on the Prevalence of Out-work.*

The Factory Acts, as a whole, exert a steady influence in favour of firms with large capital and efficient management, as soon as regulation becomes thorough and universal. The clauses relating to safety and sanitation have probably the greatest influence in this way, and do not concern us here; but those relating specially to women have also this effect. We may first notice that in general the Acts have made compulsory throughout an industry those arrangements of hours making for the efficiency both of the employees and the machines, which the more

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enlightened firms had already adopted; this tends to force out of the trade competitors who cannot keep up to a high standard and whose employees are subject to conditions detrimental to the community. For example, in most of the industries where overtime has been diminished, it is the larger firms who are best able to apply pressure on their customers to give their orders early, can make most easily internal arrangements to meet a sudden demand, and can afford to keep enough machinery and enough working-room beyond the requirements of a slack season (see the references given in the discussion of overtime; also *Yorks.*).

In this way the Acts hasten the general progress towards the use of machinery and the growth of businesses with large capital; *e.g.*, in the Bristol boot trade: 'Machinery made the factory and the employment of capital necessary, and the Factory Acts have not hindered but furthered this development' (*Boots*). The sanitary regulations, which to some extent affect factories where women are employed differently from others, have helped this development (*ibid.*). The observations of Mr. Wood, together with those of one of H.M. Inspectors, show that the prohibition of overtime for 'male young persons' in 1895 gave a great impetus to the factory system, since the smaller shops could not do without overtime, and had to give place to the factories employing power. Women being thus brought into the factories, the restrictions on their overtime acted in the same direction; thus the legislation affecting women hastened the development of the factory system (*ibid.*).

Again, we learn from Northampton that legislation chiefly 'hampered people whose methods are getting out of date for general business efficiency,' and merely anticipated the results that competition would lead to a little later (*Northampton*). We are told that in Liverpool 'the most far-reaching effect (of legislation) has been to place a premium upon the employer of labour who can afford to lay out the capital required to introduce improved methods of industry, labour-saving machines, and large premises with accommodation for additional workers in busy seasons' (*Liverpool*). The alleged acceptance of overtime restriction by large chocolate manufacturers, who can keep their premises cool enough for work on hot summer days, has been instanced as an unfair advantage taken on their part over their smaller competitors.[1] In the South Wales tinplate industry it is said that the less efficient mills have not been able to stand the expense of setting up the machinery which the abolition of women's night-work has introduced (*Tinplate*). The experience of laundries in this respect is interesting. In Nottingham, for example, the smaller laundries cannot reconcile their customers to the methods necessary to suit overtime regulations, while the larger laundries, with a different class of custom, have less difficulty (*Nottingham*); but this experience is not confirmed by the exhaustive account of laundry development given in Miss Anderson's report (*App. II.*). In this, as in other industries, it is not possible to discriminate between the effects of increasing use of machinery and of legal regulation. In the case of laundries, where the workers are mainly women and girls, we may include health and sanitary regulations under our reference; the requirements of these are said (*Nottingham, Canning Town*) to press heavily in small laundries, which indeed were the first to come under sanitary regulations. On the other side we may notice that it is more difficult

[1] *Women under the Factory Act*, by Miss Boucherett, p. 147.

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for large than for small firms to escape inspection, and for the actual history of the industry we refer to Appendix I. below.

The regulations may have various effects on the amount of work given out from large factories or workshops to small employers or to individual workers. Some of the cases have been mentioned already. Some employers (*Glasgow*, Clothing) have stopped giving out work to their regular hands, because the regulations were so troublesome. Others evade the law or continue out-work under its restrictions. Some (Stockport, see above) have increased out-work since overtime reductions. It may also be the case that work is passed on from the large to the smaller firms, to be done by them in illegal hours, or passed on again to uncontrolled workers. The Committee have not received sufficient evidence as to the circumstances in the scattered and complex clothing trades of London, Leeds, and other great towns, to express an opinion as to the relative prevalence of these methods.

We have not examined the effect of the legislation in the early years of its application in relation to this Section, and therefore have not considered whether, as has been alleged, any immediate increase of work done under unsatisfactory conditions was due to unequal incidence of restriction.

Section IV.—*Effect on the Employment of Women, and on the Re-arrangement of Methods of Production.*

This Section includes many highly involved questions, which may be analysed as follows :—

(*a*) Women may be actually excluded from particular processes ; or

(*b*) They may lose only part of the work done, the remainder being done by other workers or on other methods ; or

(*c*) The work may be re-arranged so as to be done by the same or a different number of women ; so that

(*d*) The total demand for women workers may be increased or diminished ; or

(*e*) The age or class of the body of women employed may be altered.

(*f*) In cases (*a*) and (*b*) the work may be done by unrestricted workers ; or

(*g*) By machinery, which may be more expensive or may be economical, only needing an impetus for its introduction.

(*h*) Employment of women in new directions may have been hindered.

The Committee has evidence that each of these developments has occurred in one place or another, except (*h*), which is of a hypothetical nature.

(*a*) *Exclusion of Women.*

The cases where women have been excluded from particular work in favour of unrestricted workers are extremely rare. Throughout our reports we find that the line of demarcation between men and women's work is in the great majority of cases rigidly fixed by physical suitability, by relative cheapness, or by custom. This is undoubtedly the general rule and the following exceptions are the only cases which a thorough search has brought to light in the industries investigated, where women have been displaced completely by men owing to legislation. In the printing and kindred trades : In Derby the curtailment of overtime from

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forty-eight to thirty evenings[1] was a serious inconvenience, as the larger number was needed for the 'laying on' the printing and folding machines, which is girls' work. 'At first the employers kept the young men over 18 years to do the work, but this was expensive, and as a last resort the engineers were pressed to invent a way of doing by automatic machinery what the girls had been doing before. This they have succeeded in doing, and girls have been discharged' (*Derby*). The employers, however, instead of discharging the girls from their workshop, employed them in new branches, so that none were dismissed, though fewer new ones may have been taken on. In London, one printing-house manager said: 'He would employ women for feeding his printing machines were it not for the limitations on their hours, which render it impossible to keep them when a press of work comes in,' but many others held an opinion to the contrary (*Printing*). In an article in the 'Economic Journal,' 1899, on *Women Compositors and the Factory Acts*, we find (p. 263) that among some very hesitating opinions three (out of thirty-five) employers said that they would employ more women compositors if more overtime were allowed; and one doubtful case is given of women being replaced by a folding-machine.

In last year's Report[2] some instances are given where women may have lost employment in Yorkshire and Birmingham, and cases in Liverpool exactly similar to those in Birmingham are reported; but the net loss recorded is infinitesimal.

In Sheffield the clause of the new special rules coming into force September 1, 1903, which enacts that: 'If the factory or workshop is situated in a dwelling-house, the work of *file-cutting* shall not be carried on in any room which is used as a sleeping-place or for cooking or eating meals,' is expected to prevent a number of women continuing to earn their livelihood at home, but it is too early to report on this.

We have two instances in our report from Nottingham: 'In one department of the lace trade, that of brass-bobbin winding, women are being steadily replaced by youths and men, as these latter can be employed in hours outside those permitted to women. This is necessitated by the night working of the lace machines, for when the machine stops and the bobbins come off empty, they must be re-wound at once. Old workers state that men were not employed as brass winders before the advent of factory legislation. Before this, brass-winding had been regarded as essentially women's work, and many employers still prefer women, alleging that they are more efficient workers (and in emergencies can evade the Inspector). Unsteady and drinking habits are very prevalent among brass-winders, both male and female, and this tends to encourage the employment of men, as they can more readily make up lost time.' It is necessary to give the second case in full. 'One of the largest employers in the embroidery trade said that twenty years ago women worked all their machines, but as they got busier they had been obliged to put a few men (from 5 to 10 per cent.) in also, as the hours of women were too limited. He thought it was also a question of stamina. In busy times they now worked some of the machines twenty hours per day and night, but the men dovetailed in with the women. They paid women the same wages as the men, and had taken on men because of the limitation

[1] The cause may have been either the prohibitionof overtime for girls under 18, or the reduction for women over 18; our information is not complete.

[2] Belfast, pp. 293, 299.

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of women's hours as trade increased. In their trade he said "the advantages to be gained by working the machines by night had increased the importance of male labour in comparison to female." His opinion was that the trade would be an increasing one in the future, and he considered that if the conditions of trade became so prosperous as to make it important to work night and day, people putting in new plants of machinery would probably put in male labour. It was the custom of the trade to employ women except when night-work necessitated men's labour. The trade is only comparatively a small one at present, and this was the only firm visited who employed men. Trade has fallen off this year (1903), and the above firm that last year employed ten men and 100 women now employs only four men and sixty-seven women. A woman can earn up to 36*s.* a week' (*Nottingham*).

A *South London* biscuit baker states that he would employ a few women in placing biscuits on revolving ovens if it were not that he needed overtime; other firms employed women at this work.

The prohibition since 1898 of the employment of women in certain processes involving the use of white lead has led to a considerable displacement, modified by the substitution of innocuous processes in some cases. The figures are so incomplete that we do not analyse them.[1]

(b) Substitution of other Workers in Overtime.

The instances in which women cease work at the end of their legal hours and their process is carried on by men are fairly numerous, but form a group which is not great in relation to the field of investigation. In the Committee's second report several such instances are given (p. 292). One instance is reported from the *Birmingham* tinplate industry. In *Kidderminster* the men on rare occasions work overtime on the women's looms. A vest-maker in *Sheffield* states that the men work long hours and overtime in the busy season, doing some work which women would do

[1] The numbers in the white-lead works for which the Factory Inspectors had statistics in 1897 were:

—	1895		1896		1897	
	M.	F.	M.	F.	M.	F.
White lead . . .	1780	702	1876	610	1499	563
Red and yellow lead .					151	—

In the Newcastle-on-Tyne district the numbers are given as

—	Male	Female	Total
1896 . . .	328	565	893
1897 . . .	329	571	900
1898 . . .	648	350	998
1899 . . .	741	227	968
1900 . . .	769	231	1000

It is clear that these figures are on the one hand incomplete, and on the other include many women engaged in processes still allowed to them; and there seem to be no statistics available which permit a satisfactory calculation of the number of women displaced.

One case is reported from Chester where women had been replaced by lads for white-lead processes long before the legal prohibition.

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if allowed. Another *South London* biscuit firm has to employ men on women's work occasionally 'at three times the wages.' In *printing* and kindred trades, men sometimes follow the girls at 9 P.M. in card-mounting in London,[1] and men do overtime in Bristol and Liverpool on women's work; while folding (see above) must often be done by men. In paper-making men occasionally tend cutting and glazing machines after women's hours, yet in two cases women have recently supplanted men at these machines (*Paper*). Occasionally in the watch-factory already mentioned men do women's work overtime, but do not do it so well.

In some important cases men do night-work on the same processes as women work at in the day-time. One instance is printers' folding (*London* and the Derby case already mentioned). Again, in or near *Derby* men do cotton doubling at night, and young men some of the preparatory processes for lace. There is also the very important instance of combing in Bradford (*Yorks.*), and other instances given in last year's report.[2] In these cases women would not improbably do overtime and even night-work, if allowed. The remaining case is in the South Wales tinplate manufacture, which is detailed under (*g*) below.

(*c*) *Rearrangement of Work.*

In the discussion of overtime above it was shown that the restriction of hours was often met by a rearrangement of processes. The references there given will support the following general statement: In the great majority of industrial processes carried on by women, their work is cheaper and often more efficient than any that can be substituted for it; restriction is therefore met by adaptation of manufacture or rearrangement of numbers employed and time at which work is done, women still being employed at the work. Under the headings (*a*) and (*b*) all the cases to the contrary which have come under the notice of the Committee are detailed, and all the investigators made a special inquiry on this head. The Committee therefore endorses the remarks of H.M. Chief Inspector Redgrave in 1881 [3] as being in the main applicable to the present time.

'The objection that by placing restrictions upon a certain class of labour there will be so much repugnance to the employment of that class of labour that it will be dispensed with, and the place be supplied by unrestricted labour, is not made for the first time in the history of factory legislation.

'The employment of labour by an employer is governed purely by economical principles. The dismissal from a shop of the young persons and women sewing in it must be followed by the engagement of men at a much higher rate to do their work. The question the employer will put to himself will be whether, it being a regulation that all in the same kind of trade shall be subject to precisely the same kind of restriction, it will be more economical to him to keep his shop open for fair and moderate hours with moderately paid young persons and women, or to keep his shop open well into the night with all its attendant increase of cost and with more highly-paid assistants.

'All our experience (says Mr. Redgrave) goes to show that employers prefer moderate hours under reasonable restrictions to unlimited labour. Very few employers of any class are to be found in occupations under the operation of the Factory Act prepared to say they would willingly

[1] In this connection see last year's Report (Belfast), p. 306, line 4, and p. 293, note.
[2] Pp. 291, 292.
[3] *Factory Inspector's Report*, 1881, p. 41.

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return to the old system. Some may think the present restriction upon hours of work might be somewhat loosened, but those who prophesied the dismissal of young persons from their occupation and the substitution of male adult labour acknowledge that they were mistaken, and are loud in the acknowledgment of the advantage to themselves, as well as to their employees, of moderate hours of work.'

If, as appears to be generally the case, the same amount of work is done in the restricted hours, one or more of the following alterations must occur: the hours may be the same in total, though differently arranged (for instances, see above); work in the shorter time may be more efficient, either through the help of machinery, or employment of more skilled or quicker workers, or because the better conditions cause better work (and it is generally admitted that overtime work is relatively unproductive in itself and often spoils work on the following day); or more workers may be employed. This leads us to the next headings.

(*d*) *The Demand for Women Workers, and* (*e*) *Changes in Age of Women employed.*

To what extent, if any, the older hands are penalised by higher pressure in shorter hours, and to what extent the total number employed is altered, cannot be answered satisfactorily in individual cases. Some light is thrown on these questions, however, by the general statistics of employment.

The following table is based on Miss Collet's paper, published in the 'Journal of the Royal Statistical Society,' June 1898, brought up to date from the census for 1901. The information tabulated in previous census reports does not allow of further subdivision, but for the present purpose we chiefly need to look at the figures *en masse*, because we are concerned with the *net* result of the causes which determine the number employed. Further analysis, even if practicable, would need to be carried to a length too great for this report.

A discussion of the figures up to 1891 and a general criticism of their accuracy and value is to be found in Miss Collet's paper.

Number of Females, according to the Census Reports, engaged in Occupations for gain. (*England and Wales.*)

i. *All above 10 years of age, occupied per 1,000 living above 10 years of age.*
ii. From 10 to 15 " " " " from 10 to 15 years of age.
iii. " 15 to 25 " " " " " 15 to 25 "
iv. " 25 to 45 " " " " " 25 to 45 "
v. " 45 to 65 " " " " " 45 to 65 "
vi. Above 65 " " " " above 65 "

Occupation	Division	1871[1]	1881	1891	1901
ALL OCCUPIED	*i.*	*366*	*340*	*344*	*316*
	ii.	212	151	163	121
	iii.	612	621	634	611
	iv.	315	290	296	271
	v.	293	261	250	212
	vi.	259	183	160	132

[1] Persons returned as 'retired' were included in 1871, but not subsequently.

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Number of Females, according to the Census Reports, engaged in Occupations for gain. (England and Wales)—cont.

Occupation	Division	1871	1881	1891	1901
A.—Domestic indoor servants	i.	137	123	121	101
	ii.	93	70	66	39
	iii.	297	293	274	228
	iv.	98	84	90	81
	v.	66	45	48	42
	vi.	60	26	28	20
A.—Charwomen	i.	9	9	9	8
	ii.	0	0	0	0
	iii.	2	2	2	2
	iv.	9	10	10	9
	v.	19	21	21	20
	vi.	16	15	13	11
B.—Milliners,[2] dressmakers, shirtmakers, seamstresses	i.	44	44	41	37
	ii.	6	8	12	11
	iii.	66	73	78	73
	iv.	53	45	37	32
	v.	39	37	29	23
	vi.	25	23	19	17
B.—Tailoresses,[1] including clothiers, outfitters, dealers	i.	4	5	8	9
	ii.	1	1	3	4
	iii.	6	8	15	19
	iv.	5	5	6	7
	v.	4	5	6	5
	vi.	2	3	3	3
B.—Washing and bathing service	i.	19	18	16	15
	ii.	1	1	1	1
	iii.	10	11	13	17
	iv.	20	18	16	14
	v.	37	34	30	23
	vi.	32	24	20	15
B.—Boots and shoes (including dealers)	i.	3	3	4	4
	ii.	2	2	3	3
	iii.	5	7	8	9
	iv.	2·6	3·3	3·3	3·0
	v.	2·2	2·2	1·7	1·5
	vi.	1·8	1·2	0·9	0·7
C.—Cotton	i.	32	30	29	25
	ii.	38	28	30	22
	iii.	59	58	55	51
	iv.	28	28	26	23
	v.	10	10	8·7	7·5
	vi.	3·8	1·8	1·3	1·0
C.—Wool and worsted	i.	14	12	12	9
	ii.	19	11	12	8
	iii.	25	24	23	20
	iv.	11	11	10	8
	v.	5	4·5	3·8	3·4
	vi.	2·7	1·2	0·8	0·6

[1] Mantle-makers included among tailoresses in 1901, but among milliners &c. previously.

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Males: per 1,000 over 10 Years of Age.

Occupied with	1881	1891	1901
Boots and shoes	20·2	19·1	16·3
Cotton	19·9	20·1	16·2
Wool and worsted	10·0	9·6	—
„ „ (including dealers) .	—	10·1	7·2
All occupied	832	831	837

From this table may be gathered many interesting facts relevant to the inquiry.

In the summary group 'all occupied' there is a marked decline under 15 years in 1871–81 and 1891–1901; this accounts for a considerable part of the decline in the total. In Division vi. (above 65 years) there is a steady decline (the great drop 1871–81 is presumably artificially increased by the inclusion of 'retired' persons in 1871). In Division v. there is a steady decline. In Divisions iii. and iv. (15 to 45) there is a decline in 1871–81 and 1891–1901, and a slight rise in 1881–1891.

Let us take three groups: A. Unregulated industries (domestic servants, charwomen). B. Industries thoroughly regulated before 1871 (cotton, wool). C. Industries coming under stricter regulation since 1871 (milliners, &c., tailoresses, laundries, boots).

The figures may be retabulated as follows :—

Females —	1871	*a* 1881	— 1891	*b* 1901	Ratio of Column *b* to Column *a*
Ages 15–25, occupied per 1,000 — All occupations	612	621	634	611	0·98
Group A . .	299	295	277	231	0·78
„ B . .	88	100	114	118	1·18
„ C . .	84	82	76	69	0·84
Ages 25–45, occupied per 1,000 — All occupations	315	290	296	271	0·93
Group A . .	108	94	100	90	0·96
„ B . .	81	72	62	56	0·77
„ C . .	39	39	35	30	0·77
Ages 45–65, occupied per 1,000 — All occupations	293	261	250	212	0·80
Group A . .	86	67	69	61	0·9
„ B . .	83	79	66	53	0·67
„ C . .	15	15	12	11	0·7
Above 65, occupied per 1,000 — All occupations	259	183	160	132	0·72
Group A . .	77	41	40	31	0·75
„ B . .	61	52	43	36	0·7
„ C . .	6	3	2	1·6	0·5

In the case of girls or women between 15 and 25 there has been a rapid falling off since 1881 in Group A (unregulated), a slighter fall in Group C (regulated for many decades), and an increase in Group B (coming under regulation). The fall in C is relatively less than that of males in the same industries.

With women between 25 and 45 the numbers in Group A are not much changed; in Group C the fall is the same as for males; in Group B there is a fall, though in tailoring there is a rise.

With women between 45 and 65 there is considerable fall in Groups

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B and C, and little in A. With women over 65 there is a falling-off all round.

The age group 15–25 is the most important numerically, and seems to be favoured by the growth of the factory system with all its attendant circumstances. Older women have diminished in number in all cases; but, speaking broadly, the diminution is no greater where trades have comparatively recently passed into the factory stages than in those which have long been regulated. Thus this table does not support any theory which would connect regulation rather than other circumstances with this decline; nor, of course, does it enable us to distinguish the effect of the increase of factories from that of other concurrent developments.

The falling-off of the employment of women over 45 years of age in all the occupations just dealt with is an important phenomenon. Part may be attributed to the same causes which have led to the diminution of the number employed between 25 and 45 years since 1891, and it may be hoped that this is due to diminished need on the part of married women to work outside their homes. A certain part of it is probably due to the inability of elderly women to adapt themselves to altered conditions or to the unwillingness of employers to engage them, and this may be modified naturally in the process of time. Again, the fall registered in Division iv. in 1871–1881, whatever its cause, might be expected to show itself again in Division v. in 1891–1901.

Unless the fall can be shown to be due to increasing prosperity, it suggests the necessity of careful examination of projected changes, with a view to preventing discrimination against the employment of the old. The Committee has not, however, come across any definite cases where the old are handicapped by unnecessary or injudicious legislation. Alleged cases are generally attributable to the necessities of machine production.[1]

Further light is thrown on these questions by a comparison of the returns as to the numbers employed in factories and workshops under inspection and the general census returns:—

CENSUS.—*England and Wales.*

	1881	1891	1901	
Males . .	832	831	837	occupied per 1,000 over 10 years of age.
Females . .	340	344	316	" " " "

Factory and Workshop Returns.—Percentages that Number of Females over 14 years old form of Total Number of Males and Females over 14 years.

In registered	1890	1895	1896	1897	1898–9
Textile factories—					
England and Wales .	58·9	60·1	60·0	60·6	61·0
United Kingdom .	61·1	62·1	62·1	62·6	63·0
Non-textile factories—					
England and Wales .	—	17·2	17·2	17·5	17·4
United Kingdom .	15·4	17·9	17·9	18·0	18·0
United Kingdom, less 'machinery, &c.' .	—	21·7	24·4	24·2	24·4

[1] Some people, no doubt, will instance the new rules for Sheffield file-cutting as a case in point; but they only come into force in September 1903, and it is impossible to foresee their effect, so that it is out of place to discuss them.

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Thus, so far as this evidence goes, the total number of males occupied remained stationary, and of females decreased in proportion to the total numbers living; while in factories the number of females increased relatively to the males.

Addendum to Section IV. (d) and (e).

The Committee has thought it expedient to examine in detail the following paragraphs from 'The Fall of Women's Wages in Unskilled Work,' by Miss Boucherett, 1899, p. 8, and Miss Deane has kindly sent the necessary statistics and notes from the published official returns, on which the statements are based :—

'Where (the limitation of hours) leads to dismissal of women I venture to think that the evil is great. It is certainly great to the women. To give an example: When it was suggested that bleach-works should be subject to limitation of hours of work for women, the employers remonstrated and said that as their work depended on the sun, rain, and wind, the hours were necessarily irregular, and that if women could not be allowed to work irregularly they would be obliged to dismiss them. The remonstrance was disregarded, and the result is shown in the annual report of the Chief Inspector of Factories, p. 320. In 1890 there were employed in bleaching and dyeing 49,453 males and 19,207 females. In 1895 the numbers were 57,741 males and 18,554 females. These figures show an increase of rather more than 8,000 males and a decrease of 653 females. Now, if no artificial interference had taken place, the probability is that the numbers of both sexes would have increased in equal proportion, which would give an increase of about 6,000 males and 2,000 females, so that nearly 3,000 more women would have been happily employed in a well-paid, healthy occupation than is now the fact. (In the millinery, mantle, stay, corset, and dressmaking trades the number of men has doubled, while the women have increased by little more than half. See Chief Insp. Rep., p. 320.)

'The same decrease of women employed and increase of men has occurred in several other trades, as shown in the Factory Report.'

There are no other statistics offered in the pamphlet.

With regard to these statements Miss Deane draws attention to the following facts :—

Bleach-works and dye-works came under regulation in 1860–7. The earliest official returns are for 1871. Between that date and 1890 the proportion of women increased, as the annexed table shows. The drop in 1890–5 did not bring the proportion of women down to its level of 1871, and there was no new legislation nor better enforcement of the old at that period. There is consequently no evidence that the fall was connected with legislation, but *à priori* evidence to the contrary.

Figures for separate parts of this industry are only available for 1897–8 in factories, and 1896–7–8 in workshops, and are given in annexed table. It is there seen that the numbers in open-air bleaching are very small, and that there is no significant change in the two years.

The conditions of the trades account for the changes quite independently of the Acts. Even in 1871 they were chiefly men's occupations. The work for the most part is heavy in the extreme, and the machinery used of the most ponderous kind. The great heat, the steam, the dirt,

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the constantly wet condition of the floors, and the vapours caused by the use of large quantities of chemicals, combine to render the occupation one to which the above mention of 'a healthy occupation' in which women may be 'happily employed' is not apposite.

The numbers employed in open-air bleaching (in connection with flax mills in Ireland) are a very insignificant part of the whole.

The same cause which has contributed to reduce the proportion of women in favour of men employed in the washing sheds of a steam laundry will have operated also in this trade, namely, the introduction of heavy machinery, the rotary machines, the hydro extractor, and other cognate machinery, while the use of mechanical drying horses and power-driven hot-air propellers has also contributed to the same end.

Bleaching and Dyeing.—Numbers in Factories under Inspection.

—	Males [1]	Females [1]	Females as per cent. of total
Totals: 1871 . . .	23,512	7,365	23·9
1890 . . .	48,654	18,928	28·0
1895 . . .	56,861	18,355	24·4
1896 . . .	55,172	17,848	24
1897 . . .	47,736	14,930	23·8
1898 . . .	49,450	15,650	24·0

Details for 1897 *and* 1898 (*Children, only* 1 *per cent. of whole, included*).

—	Open-air bleaching		Turkey red dyeing		Job dyeing		Other bleaching and dyeing	
	—	Per cent. of Total	—	Per cent. of Total	—	Per cent. of Total	—	Per cent. of Total
Males, 1897 .	630	—	2,721	—	1,575	—	43,261	—
Females, 1897 .	198	23·9	2,807	50·8	1,717	52·2	10,270	19·2
Males, 1898 .	799	—	2,860	—	1,821	—	44,507	—
Females, 1898 .	244	23·4	2,795	49·4	2,120	53·8	10,571	19·2

Workshops.—Job Dyeing and Cleaning.

—	Males	Females	Females as per cent. of Total
1895	139	61	30
1896	133	60	31
1897	86	84	49

Millinery &c.

As regards the statement as to the millinery, mantle, &c. trades, a reference to the appended table shows that while 1,200 more men were employed in this branch of the clothing trade in 1895 than in 1890, there is an increase in the same period of 7,750 women.

In Miss Black's reply to Miss Boucherett in the 'Women's Industrial News' of June 1898, she remarks that 'the real nature and tendency of

[1] Excluding children.

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this fact depend entirely, not upon the proportions, but upon the numbers. To come down to an imaginary example on a small scale. Suppose that in a mantle factory there were twenty women workers and one man cutter, and that, business increasing, eleven more women were taken on and an assistant cutter. This new state of affairs would be exactly represented by the above (Miss Boucherett's) statement, but yet, if you multiplied it by a thousand it would still mean that eleven thousand fresh women had come into the trade and only one thousand men.'

The additional engineers, stoker, foremen, cutters, assistant cutters and porters account for the added thousand: as the trade becomes more specialised, the subdivision of labour greater, and the use of power-driven machinery more common, the need for skilled cutters, foremen, and engineers becomes greater. In the workshops where no machinery is found, although the sub-division of labour is continually more marked, the increase in the percentage of men is less than in the factories. The Factory Act regulations as to limitations of hours are identical in non-textile factories and workshops.

The attached tables, which give all the relevant figures published by the Factory Department, show that in spite of legislative limitation of hours, which applies to all the subdivisions of the clothing trade alike, there has been a marked decrease in the proportion of males since 1890.

But the difference in the percentage of males and females, whether in the trade as a whole or in the different subdivisions of it, has nothing whatever to do with legislative enactment, but is dependent on modifications and fluctuations in the conditions of the industry: viz. the extended use of machinery, the nature of the machinery, the subdivision of work into different branches each with its skilled foreman, the influx of alien workers, as in the 'bespoke' (workshop) tailoring trade, the influence of fashion, which decrees that women's garments shall be more often cut and fitted by men tailors than formerly, and a number of other causes.

Clothing: Numbers in Workshops under Inspection.—The Percentages are of Females relative to Number of Males and Number of Females.

(Children excluded except in hats and haberdashery.)

—	Millinery			Shirts and Collars			Tailoring			Haberdashery		
	M.	F.	%	M.	F.	%	M.	F.	%	M.	F.	%
1895	3,209	144,836	98	641	8,331	93	42,116	30,786	42	—	—	—
1896	3,877	163,759	98	907	9,913	91·7	49,461	35,683	42	4,983	21,430	81
1897	3,533	170,999	98	867	9,373	91·5	51,965	37,689	42	3,771	20,220	84

—	Boots and Shoes			Hats and Caps			All Clothing		
	M.	F.	%	M.	F.	%	M.	F.	%
1895	26,734	10,139	27·5	3,252	6,589	67	80,108	221,170	73·4
1896	26,705	10,014	28	3,811	7,242	65·5	88,729	247,995	73·7
1897	25,881	10,360	29	4,167	7,715	65	91,354	258,643	74

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Clothing: Numbers in Factories under Inspection.

(Children excluded except in hats and haberdashery.)

—	Millinery &c.			Shirts and Collars			Tailoring		
	M.	F.	%	M.	F.	%	M.	F.	%
1871	1,396	9,675	87	607	5,410	90	1,999	7,215	78
1890	1,227	12,365	91	2,609	11,497	81·5	6,017	23,832	80
1895	2,424	20,103	88	2,208	18,987	90	8,292	29,813	78
1896	2,747	21,094	88	2,317	21,413	90	9,616	34,406	78
1897	2,605	20,749	89	2,681	24,310	90	10,282	34,837	77
1898-9	2,711	20,049	88	2,745	25,570	90	10,424	35,223	77

—	Hats and Caps			Haberdashery			Boots and Shoes		
	M.	F.	%	M.	F.	%	M.	F.	%
1871	5,051	6,694	57	—	—	—	11,387	6,914	38
1890	9,937	9,688	49	2,797	13,517	83	34,660	13,732	28
1895	10,217	10,599	51	4,627	26,149	85	59,384	23,420	28
1896	9,987	9,818	50	4,904	25,926	84	60,881	23,929	30
1897	10,610	10,277	49	4,398	26,911	86	63,926	26,060	29
1898-9	10,601	10,148	49	4,750	29,677	86	67,600	28,025	29

—	All Clothing [1]		
	M.	F.	%
1871	—	—	—
1890	57,077	84,334	60
1895	87,048	128,892	60
1896	90,365	136,438	60
1897	94,927	143,429	60
1898-9	99,595	149,123	60

—	The above, omitting Haberdashery		
	M.	F.	%
1871	20,449	35,908	63·7
1890	54,450	71,114	56·6

The above, omitting Haberdashery and Boots and Shoes			
—	M.	F.	%
1871	9,053	28,994	76
1890	19,790	57,382	74·4

It is not possible to separate the numerous causes which led to the change of relative numbers between 1871 and 1890. The rapid growth in number of boot factories, with their small proportion of women, causes part of the fall in that period.

(f) and (g) When Work is taken over by Unrestricted Persons or Machinery.

If the restriction of women's hours can only be met by carrying on their work without them, employers are generally put to considerable expense, and every effort is made to reduce the amount of overtime (see previous references) or to introduce machinery to do the work. There are probably many cases where the necessary re-arrangement of work has given an impetus to the use of machinery; but the Committee has only

[1] Including some small items, not contained in the adjoining tables.

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heard of two instances where the invention and introduction of a machine can be directly traced to this cause. One of these, the folding-machine in Derby, has already been discussed. The other is from the tinplate industry of South Wales. In finishing tinplates it is necessary to bran or rub them before they cool, and this is women's work. The whole process of manufacture is carried on day and night, and before regulation women used to work on night shifts as well as men. This was forbidden by the Act of 1867, but apparently the prohibition did not begin to be effective till after the Act of 1878, and night-work for women lingered on in some cases till 1885. The first general method of overcoming the various serious difficulties thus caused was to employ young men (over eighteen years old) by night, while the women worked by day. This proved too expensive, and then a method was invented of keeping the plates hot by steam jets till the women came in the morning to finish them ; but too much space was necessary for branning them all day, and the expense was considerable. Then attention turned to the possibilities of machinery, with the result that a cleaning-machine was invented (about 1893), so that by 1898 we are told that [1] 'the introduction of labour-saving machinery in the finishing branches of the tinplate industry has led to a great dislocation of manual labour. The new machines are attended to by boys, who are employed on the system of day and night shifts [2] and the system of eight-hour shifts, and as a consequence female labour in the tin-houses is rapidly becoming a thing of the past.'

We have no means of determining the number thus displaced, but the following figures afford some information :—

Number of Persons engaged in the Manufacture of Tinplate Goods.

Year	Glamorgan		Monmouth	
	Male	Female	Male	Female
1871	3,524	956	1,137	263
1881	7,354	1,839	2,497	552
1891	9,601	2,522	3,119	480
1901	8,280	1,416	749	60

There has been a further effect, in that lads on entering the trade now begin in the finishing department, and are said to become more useful workmen through knowing all the processes of the manufacture.

It seems generally admitted that the Acts, which at first threatened the welfare of the industry, have distinctly made for efficiency and cheapness ; and at no time (till the McKinley tariff) was there any check in the progress of exports of tinplates.

Some hand-branning is still done by girls by day, but this is diminishing in consequence of the requirements for mechanical removal of the dust.

(*h*) *New Occupations for Women.*

It is suggested that women are prevented from taking positions of responsibility, and from taking advantage of the possibilities of new skilled

[1] *Factory Inspector's Report*, 1898, p. 53.
[2] Boys over fourteen are allowed to work at night in this occupation.

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occupations, by their restriction from working extra hours at times of pressure; but no specific cases are given, and, considering that it is rare that work is carried on more than sixty hours a week, or that women can work efficiently for longer hours, any effect in this direction must be very small.[1]

SECTION V.—*Effect on Women's Rates of Wages and Total Earnings.*

A clear distinction must be made between changes of rates per hour or per piece, and changes in total weekly earnings; a second line of division is between changes which took place immediately after the coming into force of an Act, and the change that may be observed after sufficient time had elapsed to allow a return to equilibrium; and, thirdly, in cases where greater regularity week by week has followed restriction, we need to know how monthly and annual earnings have changed.

It may be said at once that neither theory nor evidence enable us to decide whether earnings increase or decrease after restriction.

We will first look at it theoretically. The following circumstances would tend to produce a fall: the substitution of other labour or machinery (in rates and earnings); the diminution of the product in proportion to the time cut off (in earnings, probably); the spreading the same output more regularly among the same workers (in earnings, but only if overtime had been paid at a higher rate). The following circumstances would tend to produce a rise: the attempt to produce the same output in a shorter time by workers of the same class, causing a demand for more workers (in rates, earnings might fall or rise); the diminution of the product, increasing the demand for it relative to the supply (in rates); the greater efficiency of the worker caused by the regulation of hours (fall in piece-rates, rise in time-rates, and in both cases rise in earnings); the more rapid output per hour caused by the attempt to make the same earnings in the shorter time; the greater demand for women workers caused by the introduction of machinery.

Together with these we may put the other well-known arguments, which connect efficiency with a diminished duration of weekly work, and the general problem of discovering for each class of labour the time in which the product (and in the long run the earnings) is a maximum.

From this brief analysis it is clear that it cannot be said *à priori* whether either rates or earnings will rise or fall after restriction.[2]

Nor can statistical evidence help us to a certain and general conclusion, for the effect of legislation is in most cases very much less than that of many other concurrent events. If we had evidence of specific change in a particular industry, it would tell us nothing of indirect effects possibly counterbalancing, and general statements of change would need to be of a completeness and detailed character quite impracticable to obtain, before they would support definite conclusions.

Under these circumstances the Committee can only record the particular facts as to date and nature of change that have come under their notice, without drawing any but negative conclusions.

[1] The number of women who manage laundries can be shown to be increasing by the figures given in Appendix II. below. See also the report on Coventry.

[2] Of course, a particular operative, who finds herself prevented from making a little overtime on a particular occasion, does not see either that there may be no ultimate loss to her, or that if she loses her companions may gain.

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In Mr. Wood's paper in the Journal of the Royal Statistical Society (June 1902) and in the Appendix to 'A History of Factory Legislation' are tabulated all the known published statistics (supplemented by private research) bearing on this question. The figures lead clearly to the conclusion that no permanent fall in wages can be connected with restrictive legislation, while in many cases a rise is recorded at the time, if any, when the legislation might have caused a fall. These figures are important in that they show that restrictive legislation is not inconsistent with rising wages,[1] but of course they do not show whether it furthered or hindered that rise.

Our investigators have furnished us with a quantity of wage statistics, but many are not of a nature to throw light on this question. In the textile industries (cotton, wool, carpets at *Kidderminster*, and silk at *Derby*), when the hours were reduced from 60 to 56½ in 1875, it appears that, in general, weekly time-wages were unchanged (though at Stockport they were reduced), and so were piece rates; in some cases the piece-earners were able at once to get up to their former earnings, in other cases it took some time; but the depressed state of trade which marked the late seventies made the time-limit practically inoperative for some years.[2] Similar results seem to have followed in 1902, when working hours on Saturday were reduced by one.

In the Bristol *boot* trade no permanent effect is reported; in *Northampton* piece-workers are said to make as much as before in shorter hours; no direct result has been found in *Sheffield* or *Nottingham*.

The experience of a merino factory in Nottinghamshire is very interesting: 'The reduction of hours in 1875 did not reduce wages. The men and girls at first asked for a rise of piece prices as compensation for an anticipated loss. The employer promised to consider it in a while, if the loss actually took place and became permanent. In four weeks it was found, however, that earnings were equal in 56½ hours to what they had been in the previous 60-hour week. To the employer there was, in the winter, an actual gain, as the same work being done in 3½ hours less, and the hours not worked being taken off the evening when artificial light was needed, less gas was burnt.' The same firm reduced to 55½ hours voluntarily in 1900, and again no loss was occasioned to the operatives.

Mr. Henderson[3] reports on the application of the Act of 1867 in London. In factories, he says, work is generally paid by piece, and the operatives made up to the same total in shorter hours. A manufacturer of artificial flowers told him that he got as much work out of the hands of his workpeople in 10½ hours as formerly in 12 or 14, and saved £30 in one season on his gas-bill. Mr. Henderson says that he knows of many similar cases. Concurrently with the application of the Acts in London (1867–77), there was a great increase in the demand for labour and a rapid rise of wages in London; this rise was greatest to those who came 'under the protection of the Factory Acts, namely women, young persons, and children.'

[1] In the last part of Appendix I. below, a case is given where packers in a laundry, whose class of work was specially affected by the Acts, had obtained a greater increase of wages than any other class of workers in the same laundry.

[2] *Factory Inspector's Report*, April 1875, p. 31 (where an opinion contrary to that just given is to be found), and pp. 65, 67; April 1876, pp. 57, 65, 98; *Yorks., Lancs., Kidderminster*.

[3] *Ibid.*, April 1877, pp. 21, 22, 23.

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In 1869 Mr. Baker reports[1] that the application of the 1867 Act (presumably to Birmingham) had caused a diminution of time wages at any rate temporarily, but that piece earnings were seldom diminished. As has been mentioned above, the hours in Birmingham are now in general well below the legal maximum.

Except for a few complaints as to the abolition of the possibility of payment for overtime, which, as has been pointed out, by no means prove any loss of earnings, and which are more than counterbalanced by gratitude for the shorter hours, the Committee have no record (other than those already mentioned) of any loss of wages or earnings traceable to the Acts; nor have they definite evidence of any gain, which (if it accrued), would be due to influences which take time to produce effect, and whose action would be indistinguishable from that of other causes.

SECTION VI.—*Effect on the Efficiency of Women as Industrial Agents.*

Under this heading there is little to report, for it is not often possible to distinguish the causes which may have led to efficiency. Many who say that the Acts have benefited women's health refer chiefly to the clauses relating to health and sanitation, which have no doubt had many important effects, but affect men equally with women.

Very many employers say that overtime on one evening has the effect of tiring the women so as to spoil their next day's work; and there are many instances (to most of which references have already been given) where a shortened or more regular week has resulted in a better output per worker. So far as legislation has furthered the reduction of hours to the period of greatest output, it has promoted efficiency; and in many cases the Acts have only made generally compulsory what the firms with most capital and best management had already practised.

In laundries (*London* and *Yorkshire*) and smaller workshops (*Yorkshire*), in *printing* (Bristol), in the *boot* trade (Bristol), it is said that the workers are of a better class than in the days of non-regulation. To what extent this is due to an improvement in the girls from the same social stratum, and to what to the employment of girls from a higher stratum (as is sometimes alleged), it seems hardly possible to obtain evidence.

Some of our informants say that the work (in the *Potteries*) or the moral standard of the class (in some *laundries*) has not improved.

SECTION VII.—*Effect on the Efficiency of Industrial Processes in general.*

Here again evidence cannot be conclusive.

There is a general consensus of opinion that overtime is wasteful and expensive, entailing higher wages and fixed expenses for inferior work,[2] and hence its diminution tends to efficiency. Very few, indeed, seriously desire to increase the length of the week's work, and many by their action have shown that it is best kept below the legal maximum.

On the other hand, where the occasional pressure is of a kind that cannot be removed, as sometimes in dealing with perishable materials, issuing magazines &c., the expense of keeping large additional plant to

[1] *Factory Inspector's Report*, October 1869, p. 153.

[2] This is not inconsistent with the desire of some employers to work overtime under special pressure or to meet unregulated competition.

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save a few evenings' overtime tends to inefficient employment of capital, and in those cases (rare, if they indeed exist) where women could work overtime without injury and more expensive labour has to be used in their stead, there is also inefficiency.

When restriction has promoted the factory system or encouraged the invention of machinery, it has in several cases, already instanced, hastened the use of the most efficient processes.

Any restriction of employment, whether due to legislation, Trade Union action, or the necessities of machine production, which enforces a uniform time of work on all, is certain to press differently on different persons. There will be some, of exceptional strength, to whom the existing limitation of hours will act as a check. The strong or skilful, however, are likely to find their way into industries where their strength or skill will have sufficient play; and, where piece-wages are the rule, nearly everyone can produce his or her maximum output, though the time is restricted. Others can find activities out of hours in non-industrial pursuits. Few, perhaps, will argue seriously that 55½ hours in textiles, or 60 hours in other industries (and with overtime allowed of 45 to 75 hours a year), is too short a time for a woman to exhaust her productive capacity. If they do, they must blame the general tendencies which force workers to labour together, rather than legislation.

Conclusion.

NOTE.—In the following, by the Acts is meant those parts of the Factory Acts which subject the work of women to regulations which do not apply to men (see p. 317, above).

The Committee are unanimous in expressing the following opinions, subject to the reservation noted below :—

1. The Factory Acts have reduced weekly hours of work in some cases and regularised them in many, and have nearly abolished night work for women.

2. The maximum allowed is in general greater than the number of hours worked by men in trades regulated by agreement between employers and Trade Unions.

3. In some cases legislation has enforced the custom of the better managed firms, in others it has made compulsory hours that would not have obtained otherwise.

4. In nearly all cases employers admit that the *normal* hours allowed are sufficient, and welcome the restriction; frequently the hours actually worked are less than those allowed.

5. Employees, so far as their opinions have been gathered, are unanimous in approving the restriction to the maximum allowed.

6. But for the compulsory restriction the hours would often be lengthened against the will of the majority of all concerned.

7. The Acts have had considerable effect in spreading work more uniformly through the week, month, or year, where there is occasional pressure.

8. In the great majority of cases there is approval of or acquiescence in the restriction of *overtime*; but in some few cases greater elasticity in arranging hours of work and the removal of the prohibition of overtime is urgently desired by employers.

9. It appears that in a small minority of cases the partial removal of

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the prohibition of overtime authorised by the Acts[1] tends to economy and greater ease of production without overworking the employees, particularly where occasional times of pressure follow periods of slackness and in the other cases contemplated by the Acts. There is great danger of any relaxation being abused, but when trial has shown that overtime cannot be altogether abolished (as *e.g.* where there is actual employment of more expensive labour to carry on work which women are prevented by law from doing) the authorities should give careful consideration to the circumstances of the case. The Committee have not enough evidence to recommend relaxation in any particular case.

10. There are very few cases where women's labour has actually been displaced by restriction.

11. The information as to the general demand for women's labour does not show any appreciable change that can be traced to the Acts, but the statistics are of such a nature that a change might easily escape observation.

12. Women have lost some opportunities of overtime, but it is very doubtful whether either the total number of hours worked or the total earnings made have been diminished in any important cases.

13. There is no conclusive evidence that the course of either rates of wages or earnings has or has not been affected appreciably in consequence of the Acts.

14. As regards rates of wages and the allocation of work between men and women the Acts are at the utmost among the less important of the determining factors.

15. The Acts have in some industries exerted a small but steady pressure in favour of the more efficient and of the larger factories or workshops.

16. In a few cases legislation has hastened the introduction of machinery and of new arrangements of work which have promoted efficiency of production, even where some hardship or inconvenience has been caused.

17. There is some evidence that the regularisation of hours has promoted the efficiency of women as productive agents.

18. In some important industries as a whole, and in some processes in others, the limitation of women's time has caused a limitation of men's work, but the hours even thus limited are still more than those which obtain in the majority of organised men's trades.

19. There appears to be a falling off in the relative number of elderly women returned as occupied. It is expedient that in considering legislative measures care should be taken not to diminish any desirable opportunities for their employment, but so far no want of employment has been traced directly to the Acts.

20. The Acts may have caused some inconvenience and perhaps hardship in special cases, in the main of a temporary character; the better

[1] Since 1878 a Secretary of State has had power to extend the permission to work overtime to any class of non-textile factories or workshops where certain defined special circumstances make it necessary. The Act of 1901 diminished the number of evenings on which overtime may be worked from 48 to 30 per annum for seasonal trades and from 60 to 50 for work on specified perishable articles, but gave the Secretary of State additional power to prescribe conditions upon which fish and fruit preserving and creameries may be exempt from the ordinary limits as to hours, meal-times, and holidays.

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adaptability of the more recent Acts tends to reduce these to unimportance.

21. The benefits which the Acts have conferred are in the long run great and out of all proportion to any inconveniences or injury they have caused.

Note to Report. By Miss HEATHER-BIGG.

With the greater number of the foregoing conclusions I am in complete agreement, but I cannot, in face of the facts set forth in this Report and accessible elsewhere, admit that the benefit which the Acts have conferred is out of all proportion to any inconveniences or injury they have caused. (Conclusion 21.) The statement would be true enough if made of factory legislation generally, but, limited as it is by the terms of reference to those regulations only which determine the hours and conditions of women's work, it underestimates the drawbacks and exaggerates the advantage of such regulations.

With regard to Conclusion 20, I would point out that there is no lack of evidence to show that inconvenience and hardship have been caused by the Acts. The fact that many modifications in the direction of elasticity have been conceded of late years proves that the hardships have been recognised as substantial and of a kind likely to recur.

With regard to Conclusion 19, I would say that I cannot share the cheerful optimism which hopes that some of the falling off in the employment of women over 45 may be due to diminished need on their part to work outside their homes.

APPENDIX I.

In the Appendix are given summaries and notes from the reports received by the Committee. Those points have been selected which bear most directly on the questions dealt with, and care has been taken to include all adverse criticisms of the Factory Acts. The general opinion of the employers and workpeople questioned is given as it appeared to the investigators. Some of the reports included in the list given above do not appear separately, because their gist is included in the tabulation of Sections I. to VII.

Nottingham.

(*Extracts from Report by* Principal SYMES, Dr. BOOBBYER, Mrs. DOWSON, *and* Miss ASHWELL.)

Summary.

'All employers and employees are agreed as to the beneficial effects of the sanitary clauses of the Acts, and as to the period of non-employment after childbirth.

'Trade customs seem to have been affected in Nottingham to a very small extent by the time restrictions on women's labour. In some cases the hours appear to have been shortened, but as a general rule they fall below the limit enforced by Government. The customary working day in the majority of cases is shorter by an hour than that of the Acts.

'The wages of women have apparently been little affected by the Acts. In most cases they have advanced (the exceptions being in the

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printing and in the bookbinding trades). This is apparently because of the great and increasing demand for women's labour in the particular trades carried on in this city.

'There are only two departments of trade where men and women work at the same employment.

'In both of these, viz. brass-winding and the working of embroidery machines, men seem to have been introduced mainly because of the limitations of night-work and overtime embodied in the Factory Acts. In both the custom of the trade has been to employ women, and so far the displacement of women by men has been small (but is increasing) in the first case, and in the latter is very slight.'

In the *bookbinding and printing* trades hours are generally below the legal maximum, but in one or two cases hours or overtime have been reduced, and there is a difference of opinion whether wages have been prevented from rising; in one firm it is thought that wages per head were reduced, but not piece rates. In *printing* there is no competition between men and women; one firm has put in machinery because of the shorter hours. In *bookbinding* there is little overtime, and married women formerly employed give any necessary assistance; one large employer thought the Acts had lowered women's wages; one overlooker attributed the lowness of women's wages relative to men's to the fact that 'men could be fallen back on in times of stress and emergencies, and women (because of the Acts) could not.'

Lace manufacturers and the majority of dressmakers work fewer hours than the legal maximum, except in their busy season. Almost all employers deprecate the use of overtime for both men and women, except occasionally, and then only for very short periods; yet they desire more liberty (see Section I. above).

In general in the lace, embroidery, hosiery, cigar-making, and laundry trades all employers, without exception, regard factory legislation as distinctly beneficial to women. Workpeople generally were also convinced of its beneficial effect, and indignant at the idea of protection in regard to hours of work being withdrawn. Employers state that the efficiency of women workers has not materially advanced. Most consider that legislation has made no serious addition to the difficulties of management.

In the hosiery and bleach works no serious inconvenience has been caused by legislation, except in certain cases when sufficient workers are unobtainable; nor is the general output lessened, except when workers are scarce in interdependent departments. On the one hand it is said that restriction tends to raise wages by causing scarcity of labour; on the other that more persons are introduced in times of pressure than are permanently necessary, and wages tend to fall.

Sheffield.

(*Extracts from Report by* Mr. G. I. H. Lloyd.)

Attention was paid specially, but not exclusively, to the distinctively Sheffield trades connected with cutlery, electroplate, silver work, and file-cutting. Owing to the nature of the trades machinery is but slowly introduced, and its applications are of a simple character. Only 28 per cent. of females over ten are returned as occupied in 1901, against 39 per cent. in Birmingham. The occupations in which the largest number are

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engaged are 'buffing' (*i.e.* polishing against a revolving wheel), burnishing and polishing silver and electroplate, and whetting, wiping, and wrapping cutlery; while a fair number are employed in file-cutting and cutlery work.

In the larger factories, where inspection is easy, a high standard of sanitation is being obtained, hours are nearly always well below the legal maximum; but under pressure of work the prohibition of overtime may sometimes be a serious inconvenience to manufacturers, and cases where work is taken home to be completed after factory hours are not unknown. The Act tends to encourage manufacturers to equalise work through the seasons.

In the numerous small tenement factories, out-workers, shops, &c., the conditions are not so good, and a rigid insistence on compliance with the provisions of the Acts is much more needed. The contrast between rushes of work and slack time is much more marked, especially in 'buffing'; here and with cutlery the women do the lighter work at very low wages, often working in 'teams' of six or ten, the team-master alone being responsible to the employer. So far as the enforcement of the Acts has tended to improve the conditions of work of this sort, and to bring these small shops up to the standard of the large firms, it may perhaps tend to the discouragement of out-work altogether. There is, however, not much evidence for this apart from the acknowledged endeavour of many of the larger houses to get as much of their work done on their premises as possible.

In *file-cutting*, machinery has for the last fifteen years been steadily displacing hand-work. Many hand-cutters have now taken to the machines, and a few women also have found an employment on the lighter machines. The number of hand workers has greatly diminished, and few young people are taking to the trade. In 1900 Dr. Robertson found 546 workshops in which 1,446 males and 594 females were employed; of the latter only 155 were over twenty-five years old; work generally ceases on marriage. In addition there were between 200 and 300 home-workers, nearly all women, and mostly working alone and depending on their work for their own and in some cases their families' support. The regulations now coming into force 'will probably lead to a large number of shops being closed and cause a good deal of hardship. Some of the single women now renting a "stock" in a workshop will perhaps work at home in order to escape the regulations. Others may seek to obtain exemption from the rules by using block tin or other substitute for the lead bed.[1] That the trade will be rapidly killed there is no reason to fear. Some of the work is too small and tiresome for a machine to perform, and much of the work is required in quantities too small to make it worth while to adapt a machine for the purpose; but neither will the regulations increase the proportion of in-workers, as space in a factory is too valuable to be used for a purpose which gives so poor a return.'

Summing up the investigation:—'There has been a noticeable diminution in the hours of labour and in the amount of overtime worked in busy seasons, for which the Acts have largely been responsible; regularity of work has also been encouraged. Men have been practically unaffected by

[1] The new rules are directed to diminish plumbism, arising from the use of a lead bed against which the file is held. There has been considerable controversy as to the actual danger to different classes of workers from this cause.

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the regulation of women's work. The Acts have not directly influenced women's wages; and they cannot be said to have appreciably lessened the employment of women or to have modified the evolution of the industrial processes. The efficiency of women has certainly been increased by the improvement in the general conditions of work.'

Kidderminster.

(*Condensed from a Report by* Mr. G. H. Wood)

In the census of 1901 there were 2,740 females returned as engaged in the carpet industry in the town, and 3,432 females in 'other textiles,' which consist chiefly of worsted spinning for the carpet manufacture. The number of women engaged has increased rapidly since the introduction of the 'Royal Axminster loom' in the town in 1878, which was sufficiently light for women to work; previously they had been confined to the preparatory and finishing processes. Though overtime is sometimes desired, employers have in nearly all cases refused to employ men on this new loom; men are employed to prepare, 'tune,' and keep in order the looms. The factory carpet industry has grown up under the Factory Acts; the power carpet loom was not invented till about 1852, and till then the industry was domestic. The factory system was fully developed before 1874. The effect of the Acts of 1874 and 1901 has been dealt with above in Sections I. and II. In 1875 there appears to have been a general decrease of earnings both for men and women, though not proportionate to the reduction of hours; it was made up in the course of years through gradual improvements in the machinery. The 1901 reduction did not affect time-workers, and the effect on piece-workers over the year would be inappreciable. In one firm the hours were only fifty-six before 1901; since the reduction to 55½ hours they have insisted on greater punctuality at the start, and the output has not diminished.

The demand for carpets is not uniform throughout the year, and but for the Acts the output might fluctuate more; but in any case the manufacturers have to keep a large stock.

The prohibition of overtime for women winders &c. prevents the men working overtime; it is with great effort that the women can get a stock ready for the men in advance. The men's Trade Union discourages overtime and the employers find it very expensive, and think that the present maximum is as long as the women can work efficiently. The division between men's work and women's is nearly rigid, but on very rare occasions men work overtime on women's looms.

Coventry and Derby.

(*Condensed from Reports by* Mr. G. H. Wood.)

The numbers employed in the *silk* industry of Derby and of Coventry and neighbourhood have been decreasing steadily for many decades; the ratio of adult males to females has not changed much. Manufacturers do not attribute the decline in any way to Factory Legislation. The reduction of hours in 1874 is said to have affected earnings little; that of 1902 did not affect time-workers at all and piece-workers very little. The curtailment of hours has hastened the improvement of machinery and processes.

In the *elastic web* manufacture of Derby and Coventry employers

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thought that the legislation had been good for the workers without having much influence on the industry; but they need to have enough machinery to cope with their maximum business in the restricted hours. The men sometimes work overtime on work quite distinct from women's; but the men do not like it, and employers find it too expensive except for emergencies. Employers one and all wished for permission to work overtime on a few occasions in the year. Women have not been displaced by restriction; their numbers have increased, while men have become fewer. Day-workers lost nothing by the reduction of one hour last year, and piece-workers made up much of it by greater punctuality.

We are informed on good authority that 'many *cotton doubling* factories work some of their doubling machines at night, and men work the machines that are operated during the day-time by women and girls. . . . Each man seems to tend more machines than a woman does by day.' In the *lace* manufacture youths do part of the preparatory process at night that is women's work by day, when there is night-work and the women's processes have not been carried out already on a sufficient scale.

The *cigar* industry of Coventry has grown up under the Acts, and the hours are only fifty per week. The Acts appear not to influence the trade, but one employer thinks that seasonal pressure might force on undue overtime if it were legal.

The *cycle* industry employs an increasing number of women, but the hours are only fifty-four; sometimes they work one hour more a day, but generally meet pressure by employing more hands, who are easily obtained. The Acts do not hinder the women obtaining responsible positions in tyre manufacture.

The *watch-making* in Coventry is becoming a factory and machine industry, and the proportion of women to men has increased rapidly. The trade is regular, overtime is not required, and the limitation of hours is not felt.

In Derby many women are employed in *cardboard-box* making. The hours are only fifty-five per week, and overtime has been found unnecessary and expensive, while it spoilt the work on following days; consequently enough machinery has been laid down to cope with the maximum demand.

It appears that in general in Derby and Coventry the legislation in question is no hindrance and indeed of little effect, because most of the employers are well in advance of the legal requirements.

Tinplate Manufacture. (*By* Mr. G. H. Wood.)

The gist of this report has been included in Sections III., IV., and VII. above.

The Potteries.[1]

(*From a Report by* Miss Thornewill.)

As a rule women's work is distinct from men's, though work is done in a few processes by either sex. Women act as men's assistants in so many cases that it does not pay to keep the works going when they are absent.

[1] It was thought inadvisable to make any extensive inquiry in this industry; for on the one hand so much information has recently been published, on the other, all concerned have been wearied with investigations.

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There has been no displacement of women. Before the time of legal regulation, the hours were very irregular and sometimes very long. This is shown in the Children's Employment Commission 1845. The week's work was sometimes not begun till Wednesday or Thursday. This irregularity is still shown in the absence of the clockwork regularity which is found in factory towns. In a few cases the prohibition of overtime is found troublesome, but the weight of the evidence went to prove that the restrictions as to hours had done good all the way round, making the work far more regular and more evenly distributed. Though the regularisation of hours has diminished intemperance, there is not much evidence of the improvement in domestic life that might have been expected.

Paper-making and South London Industries. (*By* Miss B. L. HUTCHINS.)

The important relevant facts given in these reports has been included in the text of Sections I.–VII. above.

Liverpool.

As Miss Harrison's report is issued as a separate pamphlet,[1] in accordance with the regulation of the Jevons scholarship, its essential points have been included in the earlier part of this report, and the details need not be given here.

Printing and Bookbinding.

In this case also a full report is expected to be published very soon; the notes on which it is based have been lent to the Committee and have had their full share in Sections I.–VII. above.

Glasgow and South Scotland.

(*Notes from* Miss IRWIN'S *reports, held over from last year.*)

As regards the *textile* industries of the South of Scotland, employers did not consider that the Acts had handicapped them, but thought that their restriction was beneficial.

The hours for *laundries* in Glasgow were, before the 1895 Act, very long and exhausting, and employers and operatives expressed a desire for legislation. The working of the Act has been hindered greatly by the elasticity allowed in the time-table. Long hours are still (1901) worked in small domestic laundries exempt from control.

Tailoring trade of Glasgow.—The enforcement of the Acts has effected a much needed reform by regulating the hours worked in factories. The effect on out-work has been dealt with above in Sections I. and III. No change of wages has been traced to the Acts, except that one employer raised wages to compensate for the cessation of out-work, and no displacement of women has been found; on the contrary, the numbers employed have greatly increased in recent years. It is generally stated that women's health and economic and social efficiency have been much improved by the legal regulation of their hours of labour.

[1] *Women's Industries in Liverpool: an Inquiry into the Economic Effects of Legislation regulating the Labour of Women.* Liverpool University Press.

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Tailoring in London.

(*From Information communicated by a Committee of the Women's Industrial Council, London.*)

Investigation was made in the neighbourhoods of Regent Street, Soho, Cheapside, Whitechapel, Borough Road, and to a less extent in other districts. It is thought that the inquiry, though necessarily incomplete, has led to facts typical of the regions dealt with. 115 employers and 56 workers or more have been seen or communicated with, belonging to many different branches of the industry, but only a small minority could give information bearing on Factory legislation. Of 12 factory employers who answered the question, all held that women were not handicapped in obtaining employment, 10 being emphatic on the point. Of 5 workshop employers, 1 thought that employment was to some extent restricted, since the women cannot help in time of pressure; 3 were clear that the Act was no hindrance, and the other was less certain. Four smaller employers strongly approved the Acts, but 1 of them thought they handicapped women. Of 14 workers who gave answers, 2 thought there was some hindrance, 4 were doubtful, 8 said that there was no effect. Of 10 employers in retail shops, 8 thought there was no hindrance, and 2 that there was some. Thus out of a total of 45 persons, 6 thought that women were handicapped, but 3 of these nevertheless approved the restriction. Several said that there was no competition between men and women. The investigators are of opinion that the line of demarcation is nearly rigid; where there is an alteration of numbers, it means a rearrangement of processes, which comes about quite independently of legislation. One vest hand said that she did not take apprentices, partly because that would bring her under inspection and regulation.

As regards hours, the detailed evidence supports the statement that the hours are less than the legal maximum in factories, equal to it in workshops, and more for home-workers; but the hours worked at home vary greatly from time to time. There is a certain amount of evidence that the restrictions as to hours are not always observed in workshops, especially the regulations as to the length of intervals for meals.

Most of the employers deny that they give out any work; one sometimes gives the girls work 'to take home to their mothers, or if a girl cannot come the next day, she is given a little to do at home instead.' But of 15 workers, who answered the question, 7 took work home, 2 of them but rarely.

Remarkable unanimity was found among employers and employees in general approval of the Factory Acts, and the few objections that were made were not to the provisions specially affecting women. Several employers maintained that when girls have worked the legal maximum they are not capable of more. One tailoress, who worked at home, said that it 'is far better to work in workshops where the Factory Acts take effect,' so as to have regular hours. 'In fact, the evidence, such as it is, is favourable to the Factory Act, and gives no ground for supposing it constitutes any real grievance.'

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London Industries in General and West London Laundries.

(*From notes communicated by* Mrs. BOSANQUET).

'In London legislation has certainly induced considerable change of custom, especially as regards conditions of work, which in many cases are notably improved. Conditions only obtaining, if at all, in the best-managed firms, have been made compulsory upon all, a process of levelling up. Notably in the laundry trade I have observed this. The laundries which come within the scope of the Act are healthy, airy, pleasant places; the floors are well drained; the women no longer stand to work in water, ventilators keep the air fresh; and the work is far more regular than formerly, though there is still great pressure at times, and consequent overwork.

'I believe it to be the case that since fur-work has been scheduled under the sections regulating out-work, it is being carried on more in factories, and less as home-work. Opinions will differ as to whether this is a good result. In view of the extreme unhealthiness of the work in the homes, I am inclined think that it is.

'Legislation has certainly affected the *hours* worked by women in the laundries and other industries which come under the Acts. I know of no direct effect upon wages, except in so far as laundry workers, being a more sober, steady set of women than formerly, are certain to earn more.

'I think it likely that indirectly the Factory Acts have encouraged the *introduction of machinery* into laundries. Many of the older set of workers object to the restrictions in a modern laundry, and employers are finding a difficulty in getting sufficient trained ironers. Concurrently there is considerable increase in the extent to which ironing machines are used. One woman minding a machine can do more work than several by hand; moreover, being less skilled and far less laborious work, it is less highly paid. To this extent one might say that the rougher class of ironer has been 'displaced' from regulated into unregulated laundries.

'I think there is no doubt at all that the present generation of laundry workers is steadier, more sober, more *efficient*, and in every way more to be relied upon than the generation brought up in the old unregulated laundries. The employers I have seen are emphatic upon this point: their only complaint at present is that they cannot get enough of the steadier women to keep up with the work.

'I know of no substitution of men for women owing to restrictive laws. I believe the printing trades have been cited; but as a matter of fact the real obstacle to women's work in this trade is the men's union, which prevents their being taught the higher kinds of work. Speaking generally, there is far less rivalry between men and women in industry than is generally supposed; they seldom do just the same kind of work. I know of no complaints as regards restriction of hours. In inquiring among small shopkeepers, *e.g.*, I have been surprised to find how much they were in favour of restriction of hours. There is a tendency to attribute loss of work &c. to legal restrictions; *e.g.*, a case was noted to me of a young widow whose foreman dismissed her on the ground that he was compelled by law to dismiss women three months before child-birth. There is, of course, no law to that effect.'

The main points referring to West End laundries in Mrs. Bosanquet's Report have been included in Sections I. to VII. above, and the subject is exhaustively treated below. With reference to them it is remarked that

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the employers and employed accept the Acts as desirable and beneficial with great unanimity; that their extension to small laundries, especially in urban districts, is desirable; and that the Acts may have favoured an increase in the supply of casual and partially employed labour, by making it necessary to take on more hands in times of pressure instead of lengthening the hours.

APPENDIX II.

NOTE:—Since laundries form an important industry which has recently come under the Acts, and in which the process of regularisation can be seen at work, the Committee think it advisable to offer a careful account of the recent history of the trade.

Economic Effect of Legislation Regulating Women's Labour in Laundries. *By* Miss A. M. ANDERSON.

DOCUMENTS. *Acts of Parliament:* Factory and Workshop Acts, 1891, 1895, and 1901. *Parliamentary Reports:* Factory and Workshop Acts Commission, 1875, Minutes of Evidence; Royal Commission on Labour, 1893 (Miss Collet's Report on Employment of Women in Laundries); Reports of H.M. Inspectors of Factories on Hours of Work, Dangerous Machinery and Sanitary Conditions in Laundries, 1894; Annual Reports of the Chief Inspector of Factories, 1892 to 1902; Census returns, 1901.

History and Summary of Legislation.

The first authoritative recommendation that the Factory Acts should regulate laundries is contained in the Report of the Commissioners appointed to inquire into the working of the Factory and Workshops Acts, 1876: 'The definition of work to be regulated by the Act should include labour in or incidental to the washing, cleaning, or furbishing any article.'

These words were *not* added to the words 'altering, repairing, ornamenting, finishing,' in the definition section of the Act of 1878 (section 93), and treatment of the question was postponed until the bill which became law in 1891 came under discussion. In that year the proposal expressly to include laundries for regulation of hours as well as conditions of health and safety was thrown out, and only certain limited powers for the Factory Department to intervene and set the local sanitary authority in movement, as regards sanitation of laundries, actually in that year became law. The Secretary of State was empowered to make a special order authorising an inspector to take steps for enforcing the law of Public Health as to effluvia, cleanliness, ventilation, overcrowding in laundries, for a specified period, if he was satisfied that the provisions of the law were not observed. Further, an inspector was empowered to notify (without such an order of the Secretary of State) to the local authority any act, neglect, or default in any sanitary matter which appeared to him to be remediable under the law relating to Public Health. (See Sections 1 and 2 of 1891.) No express powers were, however, given to the inspector (such as for factories and workshops) to enter and inspect laundries in order to inquire whether such acts, neglects, or defaults in sanitary matters existed; so that the powers to set the law of Public Health in motion (if knowledge had been obtained) remained necessarily inoperative.

The evidence before the Royal Commission on Labour, 1892–93, reopened the question, and a renewed effort to bring laundries within the scope of the Factory Acts was made in 1894. In 1893 the Chief

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Inspector of Factories presented reports from his staff on the result of inquiries made, of employers and managers on the one hand and workers on the other hand, and of observations made in the laundries where the occupiers permitted the inspector to enter. On those reports the Chief Inspector recommended inclusion of laundries under all the ordinary provisions of the Act with regard to safety and sanitation, and with regard to the ordinary hours of employment, with special exceptions for liberal overtime and for elastic arrangements as to the weekly half-holiday; at the same time he recommended special regulation in the matters of use of gas-irons, separation of stoves from ironing-rooms, drainage of floors. As regards convent and charitable institution laundries, he recommended their inclusion under the law, but that inspection should be in each case only on the express instruction of the Chief Inspector.

The Act of 1895, in the event, included all these recommendations except the *form* of regulation for hours of labour and those recommendations relating to the convent and charitable institution laundries. The Act of 1901, which consolidated and amended the general law relating to factories and workshops, merely repeats, as regards laundries (after an unsuccessful attempt had again been made in the bill to treat laundries as factories and workshops), the main provisions enacted in 1895, but made possible further control of sanitary conditions among 'out-workers' in this industry. This was done by empowering the Local Authority (now the District or Borough Council) to prohibit home-work where there is infectious disease, and by providing for returns of lists of out-workers by occupiers (and givers out of work) to the Local Authority.

The Existing Law Regulating Laundries may be Summarised as follows:—

Those laundries are covered by the provisions in the Act, applied specifically or by reference in Section 103 of 1901, which are 'carried on by way of trade or for purposes of gain.' Certain laundries are expressly exempted, but there is no definition of the term laundry. The exempted laundries are those in which the only persons employed are: (*a*) Inmates of any prison, reformatory, or industrial school, or other institution for the time being subject to inspection under any Act other than the Factory Act; (*b*) inmates of an institution conducted in good faith for religious or charitable purposes; (*c*) members of the same family dwelling in the laundry; in these cases also, if not more than two persons dwelling elsewhere are employed, the laundry remains exempt from regulation. The ordinary provisions of the law which are applied by reference in Section 103 are those which relate to sanitation, safety, and accidents, affixing of prescribed notices and abstracts and the matters to be specified in them (so far as applicable to laundries), notice of occupation, education of children, powers of Inspectors, fines and legal proceedings; these take effect as if every laundry in which mechanical power is used in aid of the process were a factory and every other laundry were a workshop. The age-limit for children (twelve years) and the time-limit for re-employment of women after childbirth (four weeks) are also applied. Laundries are further covered by certain Sections relating to home-work, *i.e.*: (*a*) Power of the Secretary of State to require lists of out-workers (Section 107); (*b*) penalty on occupiers for causing or allowing wearing apparel to be cleaned in any dwelling-house

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or building where there is scarlet fever or small-pox ; (*c*) power of the District Council to prohibit home-work in cleaning or washing wearing apparel where there is notifiable infectious disease. Section 103 itself lays down for laundries classed as factories those special sanitary regulations as regards temperature, fumes from gas-irons, and drainage of floors, which were recommended by the Chief Inspector in 1893, above cited.

The special regulations limiting hours of employment for protected persons in laundries (Section 103) are :—

The Period of Employment Exclusive of Meal-hours and Absence from Work.

—	Women	Young Persons	Children
Daily limit in 24 hours .	14 hours	12 hours	10 hours
Weekly limit . . .	60 „ (+ overtime)	60 hours (no overtime)	30 „ —

Meal-times may be fixed by the employer, but no protected person may exceed a five hours' spell of work without an interval of at least half an hour for a meal, and a break of less than half an hour in the course of five hours would not enable an employer to commence a fresh spell of five hours.

The period of employment and meal-times must be specified, but may be altered on any day provided the weekly as well as the daily limit is not exceeded. Such alteration must, however, be specified before work begins, in a notice affixed in the laundry. Holidays must be allowed under the conditions required in any factory or workshop.

Overtime for women may not exceed two hours on any day, and may not extend the daily limit beyond fourteen hours of actual work ; it may not be worked on more than three days in one week nor thirty days in a year. Notification to the inspector and affixing record in the laundry of overtime are required as in other workshops and factories.

Conditions in Laundries before and since 1896.

These being the regulations affecting laundries since January 1, 1896, what are the alterations, if any, in regard to (*a*) persons employed, either in number, age, or sex ; (*b*) wages and hours of labour ; (*c*) use of machinery and organisation of labour ; (*d*) health and efficiency of women employed, or their children ; (*e*) general prosperity of the trade ? The task is to find material for comparison on any or all of these points between the periods preceding and following the two years 1896–1897, when the law would be gradually coming into effective operation throughout the kingdom.

(*a*) *Number, Age, and Sex of Persons Employed in Laundries.*[1]

No material exists for direct definite comparison of figures. The only official figures before 1901 are those relating to the number of registered steam or factory laundries and hand or workshop laundries. No returns of persons employed in them were required from employers before the Act of 1901, and the returns made in 1902 are not yet published for the country as a whole. When they are published we shall know the number

[1] See also Section of Committee's Report dealing generally with the statistics of changes in the employment of women.

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of persons coming under regulation, and, deducting these totals from the total shown in the census, we shall be able to compute approximately the numbers not subject to regulation.

It is to be noted that in the five years following 1896 there was a very small increase of registered hand laundries, but a considerable increase of registered steam laundries, thus:—

	Steam Laundries	Hand Laundries
1896	1,069	5,026
1901	1,972	5,049

Discovery of unreported laundries would account for the whole of the increase of hand laundries, but hardly for the increase in the other column. The tendency would thus seem to be on the whole towards increase of employment in steam laundries, but nothing exact is known of the average numbers employed in either class of laundry throughout the country, although an estimate is attempted below from figures for the West London steam laundries. Mention is made by Mrs. Bosanquet of a recent increase in the number of casual women workers in Acton hand laundries, but the experience of Miss Deane, which goes back to 1893 in West London laundries, is that there has always been a considerable number (even before regulation of hours) of unskilled casual washerwomen who work for two or more hand laundries in the course of a week. The elasticity of the daily limit of hours for women in laundries would allow for the possibility of this class of labour developing or remaining stationary as it might under the influence of totally distinct causes.

The Census shows that, in all, 196,141 female persons are employed in the trade in England and Wales out of a total of 205,015 persons. As there are in all 7,021 *registered* laundries, the total number of male workers being 8,874, the overwhelming preponderance of women in the trade even since it has been regulated, and has grown so much of a factory trade, is abundantly clear. The necessary engineer for each steam laundry is not included in the total 8,874 male workers given by the Census, but even so the employment of women in an unusual degree in managing and directing (or 'laundry-keeping') is evident.

The industry is still followed mainly by adult women, but the proportion of young women and girls shows a marked increase since 1891. In that year the census showed that only 21 per cent. of the women and girls engaged in the industry were under 25. In 1901 there were 30 per cent. under 25. In London in 1901 there were 34 per cent. under 25.

In 1891 the figures were for 'washing and bathing service,' in 1901 for laundry and washing service excluding bathing. Miss Collet points out that the inclusion or exclusion of bathing service makes very little difference in the case of females; it may or may not have made a considerable difference in the case of males.

—	10 and under 15	15 and under 20	20 and under 25	25 and under 35	35 and under 45	45 and under 55	55 and under 65	Over 65	Totals
Females.									
1891 . . .	1,707	17,830	19,581	29,946	35,724	37,546	27,595	15,317	185,246
1901 . . .	2,424	28,513	28,280	32,527	33,327	33,086	24,834	13,150	196,141
Males									
1891 . . .	169	839	726	1,384	1,316	1,197	852	449	6,912
1901 . . .	178	1,066	913	2,078	1,743	1,413	871	492	8,874

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We have had access to the official employers' returns in 1902 for the West London District laundries, which district registers 303 steam laundries. In these about one-sixth of the female workers are young persons under 18 years of age, while the average number of persons employed is 24⅘.[1] The average number in factory laundries through the kingdom is probably rather higher, for in London alone are to be found the rows of small dwelling-houses converted into steam laundries by a common source of power. 'At one time it was only in a few large steam laundries that machinery was to be met with, now it is no uncommon thing to find a row of houses in separate occupation, the back yard of each of which is roofed in and packed with machinery, all driven by an engine installed at one end of the row.'[2] Nearly half of all the steam laundries in the kingdom are within London and its outlying borders. In this connection it is of interest to note that in the only European country which has a complete industrial census, and which has, to a certain extent, developed the laundry industry with the aid of steam power, in Belgium, the average number of persons employed in a steam laundry is 27.

Turning now to the earliest generalisations of an authoritative or official kind on the conditions of the laundry trade, in view of proposals to regulate, we find important evidence given to the Commissioners of 1875-76 on the Factory Acts by the manager of the Civil Service Co-operative Laundry, London. There we find, twenty years before legislation touched laundry women's labour, an outline of the earlier stages of the change of the laundry industry into the factory system, and can see the almost complete revolution that was about to be accomplished independently of legislation. The witness spoke from his own experience and from visits to all the large steam laundries in London, Kingston, Manchester, Stockport, and Scarborough. He stated that the trade was 'in a transition stage from a little cottage industry, owing to the necessities of this huge London, into more and more of a factory system,' economy of labour was being sought, 'washing women are being rapidly superseded by machines'; the economy of labour could only be effected 'in the washing, not in the ironing' processes. 'Girls are scarcely employed at all in laundries, we have only two under eighteen, and not one under thirteen.' Speaking generally, it is not common to employ girls young. The largest laundries would not employ more than 70 hands, and he mentioned instances of 40, 50, and 60 employés. Skilled labour was most needed for the ironing processes, and the supply generally was insufficient during the season. Many women would not take to the work partly because of its hard nature, partly because of the 'social stigma' attaching to it. London bricklayers' labourers' wives supplied a very large proportion of the labour. In 1892, in Miss Collet's Report to the Labour Commission, we find witnesses, laundry proprietors, giving a similar account of the source of supply of labour (*e.g.*, 'nearly all his laundresses were married or had children to support. The husbands were generally bricklayers' labourers. . . In the busy season in summer, when women were most wanted and there were fewest of them, they made things worse for the laundries by going fruit-picking and pea-picking'). We find on the other hand indication in Miss Collet's report of a growth of employment of young workers in steam laundries in the 'hottest parts.' The proportion

[1] Seventeen laundries in the West London district employ over seventy workers and seven employ over 100 workers.

[2] *Annual Report of the Chief Inspector*, 1900, p. 382.

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of married women is now probably less than it was twenty years ago, owing to the growth of employment of young women and girls in ironing (machine ironing) processes, but the census returns 1901 show still a very large number :—

		Total employed in laundry work	Working at home
England and Wales	Females, unmarried . .	86,474	22,404
	Females, married or widowed	109,667	50,642
County of London	Females, unmarried . .	20,158	2,804
	Females, married or widowed	27,204	7,604

(*b*) *Wages and Hours of Labour.*

The witness before the Commission of 1875 quoted above enables us to compare past and present as regards hours and wages for laundry workers in London. First it may be noted that he considered legal limitation of hours in London itself to be impracticable, on account of the enormous season pressure, although he considered it practicable possibly in factory districts such as Nottingham. The hours, he said, were much longer for ironers than for washers, as in the latter case the labour was being aided and superseded by machinery tended by men. Ten hours a day is about what a washerwoman works, 8 A.M. to 8 P.M., with intervals for meals : in their case it would be possible to limit the hours with the help of machinery. Ironers' work extends over 14 or 15 hours during the season, but actually, with meal-times, which are closely adhered to, the work goes on during 12 to 13 hours. Ironers will not work after 11 P.M. as a rule, nor after 10 P.M. on Saturday. 'It is the London season, and the pressure on them is so great that they are worked out by Saturday night. Occasionally they are asked as a great favour to go in on Sunday morning for one or two hours, but the next week they suffer from the want of rest undoubtedly.' In private and small laundries the hours, he says, are much longer, sometimes all night. As the workers describe it, 'they are worked out, and no doubt they are.' Ironers, he says, in the London season, earn 17*s.* to 19*s.* a week, and out of the season (if they are not 'out of work') earn from 9*s.* to 11*s.* He gives no information about washers' wages.

Miss Collet's report to the Labour Commission in 1892, and the special Report of the Inspectors of Factories on Laundries presented in 1893, show very similar conditions as to hours. As Miss Collet says of steam laundries, 'by the employers' own admission very long hours are worked' ; she gives instances of weekly hours, exclusive of meal-times, ranging from 63 to 72½ hours, and of daily periods ending at 9 P.M., 10 P.M., and 12 midnight repeatedly. In 20 out of 22 hand laundries the laundresses habitually worked longer than the day limit imposed by the Factory Act. In the special Report of the Inspectors longer and more irregular hours are cited: 'Hours are irregular and excessive, two and three nights at a stretch' (Mr. Bowling). 'In a shipping case work continued all Friday night and to noon on Saturday' (Mr. Cameron). 'Ironers work from Friday morning until Saturday at midnight (continuously . . . working 42 hours at a stretch' (Miss Paterson). 'Several persons express the opinion that the pressure which occurs frequently on Thursday, Friday, and Saturday, arises from mismanagement' (Miss Abraham, Miss Paterson, Mr. Vaughan, Mr. Shaw, and Mr. Dawson). 'The fact that many laundries, including two belonging to shipping

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companies, have voluntarily placed themselves under the Act . . . goes to prove that it is practicable for all' (Mr. Richmond, Captain Smith). The Factory Inspectors give no particulars as to wages, but Miss Collet's report gives them for both steam and hand laundries. Ironers on piece-work in one steam laundry were earning from 16*s.* to 22*s.*; machine room day workers from 10*s.* to 16*s.*, for a nominal day of 12 hours, overtime paid at the same rate as ordinary time. Finery and best ironers are quoted in other steam laundries as earning from 3*s.* to 4*s.* a day. In one of the laundries where best ironers earned 4*s.* a day, 'shirt ironers on piece-work earned from 17*s.* to 25*s.*, and collar ironers over 21*s.* in a full week.' Several employers in hand laundries, members of the Acton and West London Laundry Proprietors' Co-operative and Industrial Society, 'stated that in Acton all proprietors paid the same wages. Washers were paid 2*s.* 6*d.* a day, of 12 hours, including meals, with 2*d.* a day for beer. Ironers, 2*s.* 6*d.*, 2*s.* 9*d.*, and 3*s.* with beer. All were paid 3*d.* an hour for overtime, and deductions for short time were made at the same rate.' Miss Collet considered that the comparative uniformity of daily wage which she found in Acton must be largely due to the comparative absence of young persons. 'In Acton I gathered that it was the custom to send girls to service on leaving school, or to the steam laundries, and for them to leave later, or when old enough and strong enough for the work in the hand laundries.'

As regards hours of labour since 1896 we may take it that roughly and broadly in the registered laundries the ordinary hours of labour do not exceed those legal, with the addition of overtime in the case of women over eighteen years of age. At first no doubt there were many infringements of the legal limits, and exceedingly long and trying days of work, of which the illegality could hardly be proved, have in too many cases occurred. Legal hours that extend to far greater length than in any ordinary factory or workshop are still to be found on the days from Tuesday until the end of the week; night work is legal and Sunday labour is not prohibited by the Factory Act. Still the exhausting continuous periods, night following day towards the end of the week, instanced by the Factory Inspectors in the report of 1893, have certainly been stamped out by the Inspectors in all but comparatively rare cases, and the use of the overtime exception shows no sign of steadily increasing in this industry. This may be seen in the following extract from official returns of overtime. Between 1896 and 1897 any increase so small as is shown would be attributable to improved reporting and endeavour to conform to the law :—

Year	No. of Laundries Reporting Overtime		No. of Notices of Overtime		Total Notices Overtime in Laundries
	Steam Laundries	Hand Laundries	Steam Laundries	Hand Laundries	
1866. . . .	not given		2,694	1,884	4,578
1897. . . .	"		3,625	2,094	5,719
1898. . . .	336	154	4,151	1,639	5,890
1899. . . .	412	159	4,817	1,339	6,156
1900. . . .	404	104	4,143	857	5,000
1901. . . .	550		not given		5,394

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Prosecutions by Inspectors on account of employment beyond legal limits of protected persons may be summarised as follows :—

—	1896	1897	1898	1899	1900	1901
In the case of Children . . .	—	—	1	1	—	5
„ „ Young Persons . .	11	13	20	32	13	47
„ „ Women . . .	8	53	26	38	—	44

In the special report to this Committee from the Nottingham Investigators it is stated that the smaller laundries find restricted daily hours a serious inconvenience, contrary to the experience of the steam laundries. In the official overtime returns it appears that no claims have been made by occupiers of workshop laundries in Nottingham for overtime, whereas in a small number of factory laundries the exception has been made use of. It is noteworthy that over the whole kingdom occupiers of factory laundries make a far more general use both absolutely and relatively of the overtime exception than do the occupiers of workshop laundries. It may be that illegal and unreported overtime is more often resorted to in the latter case, although this is not borne out by the experience of the Factory Inspectors in West London. It is more probable that the elastic and movable limits legally permissible for each day amply serve the purpose of the smaller laundry without addition of overtime, and that the steam laundries organising their daily period on more rigid lines throughout the week, more readily resort to additional hours when a pressure arises. Mrs. Tennant forwards the statement of an occupier of a large steam laundry that before the introduction of the Factory Act the hours were 7 A.M. to 6.30 P.M., with two hours for meals, Monday to Wednesday inclusive; 7 A.M. to 8.30 P.M. Thursday and Friday; and on Saturday until work was finished, but never later than 8.30 P.M.; on every day two hours for meals. Thus the daily limit never exceeded 11½ hours, and the weekly total 63, not including meal-times. Yet he says, 'On the introduction of the Factory Act our hours were increased.' This could only be legally in weeks in which overtime was permissible, but possibly the average in the less busy times rose. This evidence comes from a seaside resort, but there is much evidence to similar effect from the factory inspectors' reports in the year following the application of the Act. 'The "coming under the Act" has been found not to bring the expected relief, but to give sanction to the late hours and long day's work hitherto regarded as unnecessary evils tolerated in an unregulated industry. . . . The provision for an extra meal when working overtime has not been made applicable . . . and the women found themselves legally employed from 5 o'clock, the end of tea-time, till 10 P.M. without any break. . . . The class who would seem to be really benefited by the Act are the packers and sorters, whose hours of employment commonly reached over seventy (often nearer eighty) in the week' (Miss Squire). The hours in some parts of the country remained stationary, notably in Yorkshire and Lancashire towns. 'Managers inform me that they could not work up to the sixty hours limit if they wished, because better conditions could be obtained by their workers in the mills' (Miss Anderson).[1]

We have no materials for a definite comparison of rates of wages in different parts of the country, but there is a consensus of opinion that in

[1] *Annual Report of the Chief Inspector*, 1896, pp. 67, 68.

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London wages have risen. The estimate of the general manager of a large laundry company with various branch establishments, that piece-work wages have risen for ironers in the ten years, from 1893 to 1903, 10 per cent. all round, is certainly applicable in other steam laundries as well. The following is his table of rates of wages for different classes of workers :—

Comparison of Wages in Laundries.

—	1893				1903			
	s. d.	£ s. d.			s. d.	£ s. d.		
Packers . .	From 5 0 to	18 0	per week		From 10 0 to	1 0 0	per week	
Markers . .	„ 5 0 „	18 0	„		„ 6 0 „	1 0 0	„	
Washers (men and boys) . .	„ 11 0 „	1 6 0	„		„ 14 0 „	1 6 0	„	
Washers and scrubbers (women) .	„ 2 0 „	2 6	per day		„ 2 6 „	3 2	per day	
Dryers . . .	„ 1 9 „	2 0	„		„ 2 0 „	2 6	„	
Folders . .	„ 1 6 „	2 3	„		„ 1 6 „	2 3	„	
Calenderers . .	„ 1 0 „	2 0	„		„ 1 0 „	2 4	„	
Manglers . .	„ 2 0 „	2 6	„		„ 2 0 „	2 6	„	
Examiners . .	„ 15 0 „	1 0 0	per week		„ 18 0 „	1 0 0	per week	
Starchers .	„ 2 0 „	2 3	per day		„ 2 0 „	2 3	per day	
Preparers . .	„ 15 0 „	18 0	per week		„ 18 0 „	1 1 0	per week	
Ironers . .	„ 1 0 „	3 0	per day		„ 1 0 „	3 9	per day	

No class of worker would seem to have benefited more than the packers, whose hours have been so considerably reduced by the Act. The washers, men and boys, more often men, the folders and the manglers, alone appear to have remained stationary, or nearly so, in wages.

(*c*) *Use of Machinery and Organisation of Labour.*

The development of the industry from the domestic to the factory system has already been referred to in quotations from the Factory Act Commissioners' Report of 1875-6. No more striking contrast can be produced than that between the account given by the principal witness of the organisation of the work, then, and in the latest reports of the Factory Inspectors. According to his experience in 1875, whereas machinery was becoming much more largely employed in washing processes, the only things which could be 'ironed by machinery, are things as straight as a piece of paper, tablecloths, pillow-cases. . . . You could not put a shirt into a machine to be ironed or anything with gathers in it. . . . The mechanical irons heated by gas at the Army Clothing Factory would be totally useless with respect to linen.' For some time it has been a common-place that the most elaborate developments of laundry machinery are to be found in the fine ironing departments of body-linen of all kinds, and of this the most marked consequence has been the development of employment of girl-labour. The proof of growth of use of ironing-machinery is to be seen in the fact that more than half of the total accidents reported from laundries are caused by ironing-machinery ; in 1902, 152 out of 268, in 1901, 148 out of 289, in 1900, 111 out of 240.[1] In her report for 1900, Miss Deane referred particularly to the extent of subdivision of labour and use of labour-saving machinery in this branch.

[1] For details see analysis, pp. 162 and ff. in the *Annual Report of the Chief Inspector* for 1902.

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In some cases 'a single shirt will pass through seven or eight different machines in the process of ironing alone.' As regards use of machinery generally in smaller as well as larger laundries, Miss Deane stated in 1900: 'The old-fashioned washerwoman is fast disappearing, and is superseded by the enterprising young "laundry proprietor," who turning the tubs out of the back-kitchen fills their place with washing machines, and connecting them with a little gas-engine . . . blossoms forth as the owner of a factory laundry ready to deal with six times the amount of work. . . . Side by side with this development in the smaller laundries is to be found the rapid multiplication of the large companies and syndicates, certain of which own as many as a dozen or more fine well-equipped laundries . . . organised into departments, in which the division of labour is at least as marked a feature as in the majority of non-textile factories.' In the smaller factory laundries in the same district organisation is not developed in the same way. 'The labour-saving methods adopted in well-organised businesses are ignored, and in many places the work is carried on . . . as it was before power was introduced, and the output was probably not a fifth of what it is at present. This is to me one of the most striking features of the laundry development. Machinery of an expensive and intricate kind is bought and installed without as far as one can judge an effort being made to secure that the most shall be made of it. Even the risks attending its use are very imperfectly appreciated' (Miss Paterson, 1901). 'The number of steam laundries on our register has increased by over 13 per cent., the number of hand laundries by over 9 per cent. . . . Most of the additions to steam laundries have been by transformation of the hand laundry through introduction of motor power' (Miss Anderson, 1901). There is nothing to show that an impetus was given by the Act to the introduction of machinery. Possibly such an impetus might have been given by the more rigid limits of ordinary factory hours.

(d) and (e) Health and Efficiency of Women employed, and Prosperity of the Trade.

The foregoing account of the organisation and hours of labour of women in laundries, before and after limits were introduced by the Act of 1896, indicates that no clear estimate can be formed of the gain to women in health and efficiency by the provisions applying to women (as distinguished from men). As lately as 1900 the Inspector's reports insist on the immense practical difficulty of enforcing, at all closely, the daily and weekly maxima of hours. In that year the Secretary of State issued a prescribed form for notice of period of employment, the use of which was binding on occupiers who altered at any time the notice of employment for the day, the object being to secure closer observance of the legal limits by showing at any moment the proposed total period for the week, as well as for the single day. In so far as the law has checked, and this it certainly has done in a considerable degree, the excessively long night and day turns of work at the middle and end of the week, gain must have accrued to the workers in lessening the number of cases of complete exhaustion. No systematic inquiry into the system of liability of laundry workers to special forms of disease has, so far as we know, been reported before Miss Deane's report for 1900 (see Annual Report of the Chief Inspector, pp. 383 and ff.). She gave figures from examination of records

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at poor law infirmaries in typical laundry districts which brought out the greater liability of laundresses, as compared with women of other occupations treated in those infirmaries, to ulcerated legs and to phthisis. Further, she stated that the 'figures supplied by the records of the cases attended by the Kensington District Nursing Association show a large proportion of ulcerated legs and of forms of internal disease aggravated by standing for long hours. . . . I was struck by the absence of any particular liability to skin disease, for on all hands I had been informed that washerwomen were not uncommonly afflicted by a local inflammation on the hands and arms, due, it was thought, to the action of soda, soap, and other chemicals. . . . The effect of the occupation was noticed in the out-patients' department of St. Mary's Skin Hospital some years ago, but had since almost disappeared. The immensely increased use of machinery in the process of washing (even in the very small hand laundries the hand-turned washing machine is often found) may account for this difference.' In her report for 1902 Miss Deane quotes interesting later figures from the Medical Officer of Health of Battersea to show the special liability of girls from fifteen to twenty-five years (mainly packers, sorters, calender workers, and machine ironers) to phthisis. 'They work either in sorting the soiled linen or in the steam and heat and gas-laden atmosphere of the machine room. . . . The constant exposure to steam, standing on wet floors, the great heat in which the work is carried on, and the long hours at exhausting work, amply explains the tendency to pulmonary disease. The badly arranged floors in even large wash-houses are a constant source of discomfort, and probably of ill-health, to workers.'

For the latter classes of complaint the special regulation for laundries, relating to steam, temperature, drainage of floors, are admirably calculated to establish an amendment, even though the hours are still so long as to aggravate any constitutional liability to ulcers or internal disease associated with long standing.

It must be carefully borne in mind that these special provisions for the hygiene of steam laundries were enforceable earlier in hand or workshop laundries under the more general provisions of the law relating to public health by the local authority. Thus, it cannot be maintained that larger laundry-proprietors were given any advantage over their poorer and smaller rivals through the cost of conforming to the sanitary provisions of the Factory Act. Under the Kensington Vestry, for example, workshop laundries were registered, inspected, and brought gradually into conformity with general sanitary requirements years before steam laundries were affected by the Factory Act.

No authentic case has been established of disappearance or failure of workshop laundries through application of the standards either of the Public Health Act or of the Factory Act.[1] On the contrary, the evidence of the factory inspectors goes to show increased and increasing prosperity among smaller occupiers. The readiness with which costly machinery is installed in small dwelling-houses and the steady transformation of small hand-laundries into small factory-laundries, negatives the idea that the safety and hygienic clauses of the law hamper the small proprietor. It

[1] At the same time occasional references of Factory Inspectors to the tendency of occupiers to dismiss a third outside worker when they learn that a third brings them under the Act, must not be overlooked. Cf. *Annual Report*, 1902, p. 186.

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must not be forgotten that in this industry, as distinguished from manufacturing industries, the employer has not the cost of raw material to add to the cost of labour and plant, and this may account for much rapid development of small businesses at the outset.

APPENDIX III.

[Subject to Amendment.]

The Legal Regulation of Women's Employment and Infant Mortality.

The Committee have made a special attempt to find whether any relation can be traced between changes in the law (regulating or prohibiting women's work in dangerous trades from time to time, and prohibiting their employment within four weeks of child-birth in 1891) and infant mortality, and have obtained some valuable opinions from Medical Officers of Health, but have not found any definite evidence of any direct connection.

A circular letter was sent to sixty-one Medical Officers of Health, chiefly in those towns where numbers of married women were employed, stating the changes in the law that might be expected to have some effect in this direction, and asking for statistical evidence and opinions. Only sixteen replied, and most of these even had no definite information to give. The general opinion was that high rates of infant mortality were chiefly due to ignorance and carelessness in feeding infants, and its main variations from time to time were traceable to the weather and its effects on the prevalence of summer diarrhœa. Nearly all who gave information agreed that even the comprehensive law of 1891 could not produce any effect visible in vital statistics. Dr. Greenwood (of Blackburn) writes that no material reduction of infant mortality was thus caused; but that 'the nursing out of children while the mothers are at work, after the child is one or two months old, together with irregular feeding with improper and unclean food, and the general ignorance of the principles of domestic hygiene' cause high rates of mortality. The Medical Officers of Health of Leek and Batley were in favour of a longer period of prohibition.

The Committee made other attempts at investigation on this question, but in every case the inquiry broke down without result.

Some information, however, was obtained which may prove useful for further research on an allied question, viz., whether employment of married women in factories has any definite relation to infant mortality. Dr. Erskine Stuart instituted an inquiry in Batley as to the occupations of mothers whose children had died under one year old, and he and Mr. Lindley have kindly sent the details. Between May 7, 1901, and August 7, 1902, the deaths of 200 children under one year came under their notice. The mothers were by occupation weavers (30), condenser minders (6), rag-sorters (16), feeder-minder, mill-hand, reeler, mender, and laundry work (1 each); the remaining 143 are given as engaged in 'housework.'

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As regards age at death we have the following :—

Occupation of Mother	Ages of Children at death				Total
	Under 1 month	Over 1 and under 3 months	Over 3 and under 6 months	Over 6 months and under 1 year	
Housework . .	34	44	22	43	143
Mill-work &c. . .	18	8	14	18	57

While 28·5 per cent. of these deaths were of children whose mothers' occupations were away from home, only 21·4 per cent. of the married women or widows of Batley were (according to the Census of 1901) so occupied.

These figures are, of course, quite insufficient to support any conclusions by themselves, but suggest a useful and simple method of inquiry.

The general tables of occupations of married women in towns and of infantile mortality do not appear to suggest any close relationship between the two, and the great difference in sanitation and customs between town and town would lead us to expect this result. But Dr. G. Reid (M.O.H. Staffordshire County Council) has continued his researches on this subject, and kindly placed his results at the disposal of the Committee. He finds that in Staffordshire there are two groups of towns which were from the sanitary point of view similar in most respects, but that in the northern group (where many women were engaged in pottery) the rate of infant mortality was much higher than in the southern group (where relatively few women were occupied away from home).

Pursuing the idea thus suggested, he compiled the following table :—

Class according to percentage of married and widowed workers to female population between 18 and 50 years	Number of Towns	Total Population 1901 Census	Deaths of Infants under one year per 1,000 registered births		
			1881–1890	1891–1900	1901–1902
I. 12 per cent. and over	5	132,299	195	212	192
II. Under 12 per cent. and over 6 per cent.	13	263,868	165	175	158
III. Under 6 per cent. .	8	131,508	156	168	153

From this he concludes that 'in the absence of any other apparent reason the excessive mortality in the first group compared with the second and third, and in the second compared with the third, is attributable to the nature of the trades carried on as affecting the facilities for the employment of women away from home, and as a consequence the proportion of wholly artificially fed to entirely or partially breast-fed infants. While [he is] prepared to admit that the practice of mothers engaging in factory work and continuing at work practically up to the day their children are born may, in itself, prejudicially affect the lives of their children, [he maintains] that the injury arising from the entire deprivation of mother's milk during the early months of the child's life is far more serious.'

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Dr. Reid also supplied the more detailed information leading to the following table and calculations by Mr. A. L. Bowley :—

District	Population 1901 Census in thousands	Percentage of Married and Widowed Workers per Female Population between 18 and 50 years	Deaths of Infants under one year per 1,000 registered births		
			1881–1890	1891–1900	1901–1902
	p	*m*		*d*	
Longton	36	23·8	217	241	210
Leek[1]	15	20·9	148	148	166
Burslem	39	17·3	191	201	190
Fenton	23	17·2	180	206	173
Tunstall	19	14·2	207	218	197
Stoke-on-Trent	30	11·6	158	174	173
Newcastle-under-Lyme	20	10·1	148	200	167
Stone	6	9·9	130	129	148
Quarry Bank	7	8·3	159	155	125
Bilston	24	8·2	190	208	185
Willenhall	19	7·8	158	198	182
Smallthorne	6	7·6	179	167	171
Rowley Regis	35	7·3	156	162	151
Brierley Hill	12	7·2	173	169	139
Stafford	19	7·2	129	132	107
Ledgley	16	6·7	185	155	128
Smethwick	55	6·7	173	162	148
Darlaston	15	6·3	193	220	206
Wednesfield	5	5·0	153	150	136
Coseley	22	4·9	153	172	168
Wednesbury	27	4·8	165	176	155
Tipton	31	4·6	163	179	150
Cannock	24	4·3	143	163	145
Brownhills	15	4·0	152	141	142
Kidsgrove	5	4·0	155	171	206
Short Heath	4	3·7	143	161	134

These details make it possible to calculate a correlation coefficient between occupation and mortality.

Taking the columns m and d only, and counting the towns as of equal importance, the formula $\frac{\Sigma \mu \delta}{n \sigma_1 \sigma_2}$, [where n is the number of towns, $(\mu_1 \delta_1)$ $(\mu_2 \delta_2)$ . . . the deviations in columns m and d from their average, and σ_1, σ_2, the standard deviations of these columns,] gives ·47, with probable error ·1 ; this gives evidence of some correlation, but, as the coefficient is only five times its probable error, the evidence is not very conclusive.

If we now weight each deviation with the population (column p), the formula $\frac{\Sigma p \mu \delta}{\sigma_1 \sigma_2 \Sigma p}$ gives ·57, with probable error ·07 (the standard deviations being calculated afresh).

We may say, then, that the excess or defect of proportionate occupation of married women is shown by these statistics to have a relation to

[1] Leek is in advance of the other towns in sanitary matters and is in a healthy position.

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the excess or defect of infant mortality, but that the connection is not very close and that the evidence is not sufficient to measure it exactly.[1]

[NOTE.—Reference may be given on this subject to the Reports of the Medical Officer of the Privy Council between 1859 and 1872, especially the Appendix to the fourth report; to 'Papers relating to the Sanitary State of the People of England, 1858;' and to the evidence given before the Factory and Workshops Acts Commission of 1875 by Mr. Foulkes and Mr. Baker.]

APPENDIX IV.

Recent Legislation Abroad relating to Women's Labour.
By E. W. BRABROOK.

Since the Report of the Committee on Women's Labour was agreed to, I have been favoured by the Office du Travail of Belgium with a copy of their 'Annuaire de la Législation du Travail' for 1902, which contains the text of all the laws relating to labour passed in that year in various countries. It may be worth while to supplement the particulars relating to foreign legislation given in the second report of that Committee by noting those which relate to women's labour.

In *Germany* many ordinances of the Federal Council have been made forbidding the employment of women in industries where great heat or motor power is used or the work is very exhausting, viz., January 31, 1902, in chicory manufacture; March 5, in glass works and in the blowing of glass; March 5, in sugar works, sugar refineries, and works for extracting sugar from molasses; March 20, in the extraction of stone from quarries; coal mines and mines of zinc and lead in the regency of Oppeln; May 27, in rolling mills and forges.

In *Austria* a law was enacted on July 28 for the regulation of railways, which, among other things, forbade the employment of women on night work or during the four weeks after child-birth.

In *Spain* a law was enacted on June 26 limiting women's work to 11 hours a day, or 66 hours a week.

In *France*, by a law of March 21, women are not to be employed in cleaning, inspecting, or repairing machinery in action.

In *Italy*, by a law of June 19, night work is prohibited for women.

In several of the States of the *American Union* laws have been made regulating the labour of women. In Louisiana, July 24, women are not to be employed more than 10 hours a day, or 60 hours a week, and to have an hour allowed each day for dinner. In Massachusetts, June 3, the limits were fixed at 10 hours a day and 58 a week. In Rhode Island, April 4, the same limits were enacted. In the State of Washington (not D.C.), on March 11, 1901, work was limited to 10 hours a day, and seats were ordered to be provided. The same provision as to seats was made in Wyoming on February 13, 1901. Finally, on April 2, 1902, the State of New York enacted that the earnings of married women should be their own. It seems wonderful that such an enactment should be necessary.

[1] In words, a deviation from the average of 2·5 in column *d* may be expected with a deviation in the same sense of 1 in the numbers in column *m*.

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The Resistance of Road Vehicles to Traction.—Report of the Committee, consisting of Sir J. I. THORNYCROFT (*Chairman*), Professor H. S. HELE-SHAW (*Secretary*), Mr. T. AITKEN, Mr. T. C. AVELING (*Treasurer*), Professor T. HUDSON BEARE, Mr. W. WORBY BEAUMONT, Mr. J. BROWN, Colonel R. E. B. CROMPTON, Mr. B. J. DIPLOCK, Mr. A. MALLOCK, Professor J. PERRY, Sir D. SALOMONS, Mr. A. R. SENNETT, *and* Mr. E. SHRAPNELL SMITH. (*Drawn up, at the request of the Committee, by the Secretary, assisted by* Mr. J. F. GILL, *B.Sc.*)

[PLATE XI.]

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I. *Results of Trials made with Committee's Dynamometer.*

IN the last Report the new dynamometer made for the Committee was described and illustrated, together with an account of the calibration of the apparatus.

It will have been noticed in the drawing of the instrument that a small screw-down valve was fixed in the circuit of tube which transmits the pressure from the plunger to the recording gauge, this valve being for the purpose of throttling the flow of water, and thus damping the oscillations of the pencil. The principal dimensions of the valve are as follows:—

Width of seat	·008 inch
Smallest diameter of seat	·1595 „
Largest „ „	·1693 „
Pitch of screw	·046 „

It was found that to produce sufficient damping action it was necessary to have this valve off its seat by an amount of not more than ·0153 inch.

It was pointed out by Mr. A. Mallock, F.R.S., of London (a member of this Committee), that the flow under a constant pressure of a fluid through a thin film-like orifice such as this, might be different in one direction to what it would be when flowing in a reverse direction, owing to the stream-line formation not being symmetrical about the constriction.

If such were the case the true mean pressure would not be recorded, but some pressure, either greater or less than the true mean, according to which side of the valve was next to the plunger.

Experiments were made to determine the minimum orifice that might be used, and it was found that equal flow from either side did not occur until the valve was opened by at least half a turn, this corresponding to the valve being raised from its seat a distance of ·023 inch. So that there should be no doubt about the orifice being too small, the experiments were conducted with the valve open by a considerable amount, the damping action being obtained by squeezing the rubber tube which connected the gauge to the dynamometer by suitable clips placed on the tube some distance from any change in cross-section. By this means the

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stream-line flow was kept perfectly symmetrical about the constriction, and hence the true mean pressure was recorded.

Mr. Mallock has suggested the adoption of a length of resistance tubing (say 1/60 inch bore) to attain the same end, and this will be fitted for subsequent trials.

Experiments.

The first experiments conducted with this dynamometer were mentioned in the last report and the results were indicated by means of wall diagrams. The results then obtained have been carefully gone into and from them the following curves have been plotted.

Experiments with Iron Tyres.

These experiments were conducted on a portion of Regent Road, Bootle, which is paved with setts 6 inches by 3 inches, having a regular but fairly rough surface, with a 1-inch gap between the joints. Regent Road runs along the line of docks, and is in consequence free from gradients; it is, however, so crowded with vehicles during the day-time that it was found necessary to conduct this series of experiments during the night.

The wheel used was a light lurry-wheel, 40 inches diameter, having a 3-inch iron tyre slightly rounded in section.

The axle was tilted up out of the horizontal at one end so that the wheel—which was slightly coned—could take up a position exactly similar to the lurry wheels in general use; it was mounted on a pair of springs 3 feet 2 inches between the centres of attachment, each spring comprising six plates $2\frac{1}{4}$ inches by $\frac{5}{16}$ inch.

Three runs were made over this particular route with loads of 392, 672, and 952 lb. respectively, at speeds of from 5 to 14 miles per hour.

The results of these trials are plotted in fig. 1, with total tractive effort (inclusive of axle friction, &c.), as ordinates, and velocity as abscissæ.

It will be noticed that for each curve the tractive effort increases with the velocity, but these curves and all subsequently obtained are concave downwards, showing that the rate of increase of tractive effort diminishes with the velocity. This may be due to the fact that as the wheel travels faster it has less time to fall into the little hollows in the roadway, merely skimming along the tops of the ridges.

Well-laid setts under these circumstances, even with wide deep gaps, form a perfectly smooth track at high speeds. This is well brought out in fig. 4, which shows a smaller tractive effort for setts than for macadam.

On looking into the matter, this is as it should be. Consider two perfectly level roads, one made with setts and the other with macadam: the setts present a surface which is extremely hard, although irregular, but this irregularity with well-laid setts is more apparent than real, as the tops of the setts themselves are smooth and level and all in the same plane.

The macadam, on the other hand, although quite level, is not nearly so hard as the stone surface, and is, moreover, covered with a thin layer of dust or fine gravel, which, as is well known, retards the progress of a vehicle.

Experiments with Pneumatic Tyres.

A series of experiments were made with a pneumatic-tyred wheel 24 inches diameter, $2\frac{3}{4}$-inch tyre. This was a wire-spoked wheel of the type used on light voiturettes; it was mounted on the same springs as

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the lurry-wheel mentioned previously, but they were reduced in strength by the removal of four plates, so that each spring consisted of two plates 3 feet 2 inches long, $2\frac{1}{4}$ inches wide, and $\frac{5}{16}$ inch thick.

This series of experiments was conducted on a level stretch of macadam road, the surface of which was in fairly good condition, slightly wet in places; runs were made with loads of 315, 427, 539, and 651 lbs. respectively.

FIG. 1.—Tractive-effort Velocity Curves for 40" Iron Tyre on Setts.

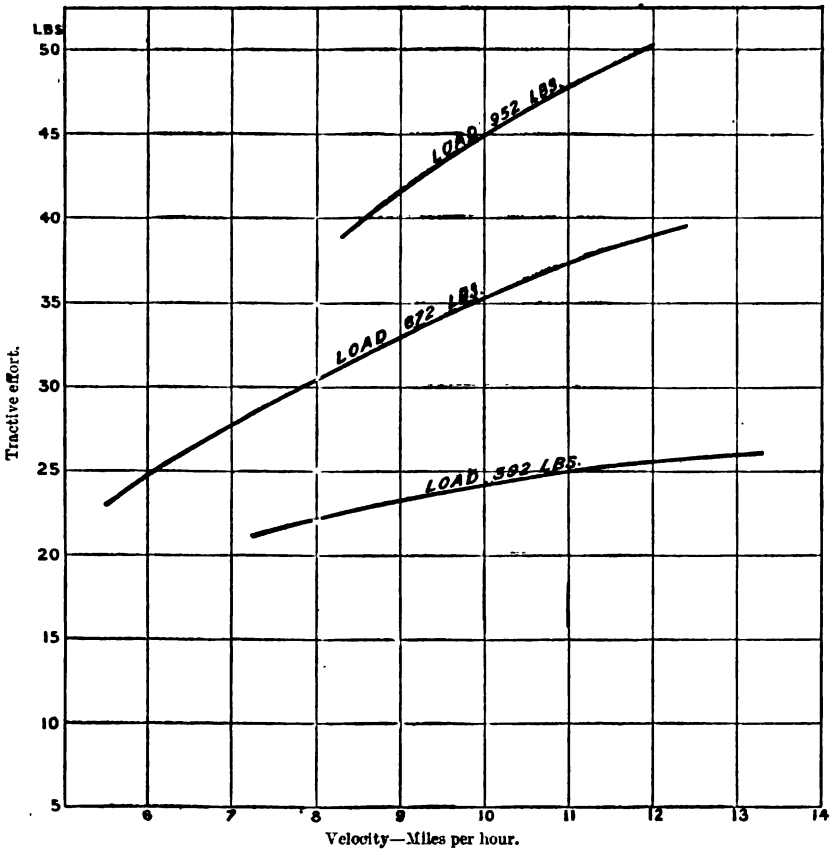

Fig. 2 shows tractive effort and velocity plotted for each of these loads. It will be noticed that the ratio of tractive effort to load for these curves is very nearly constant, and that the tractive effort increases slightly with the velocity. Sufficient results have not yet been obtained to enable this Committee to state definitely the law relating to tractive effort and load, but the results of the experiments that have been made agree with those obtained by such pioneers in this research as General Morin, M. Dupuit, M. Michelin, and others. Assuming for the time that the tractive effort is directly proportional to the load, a curve has been

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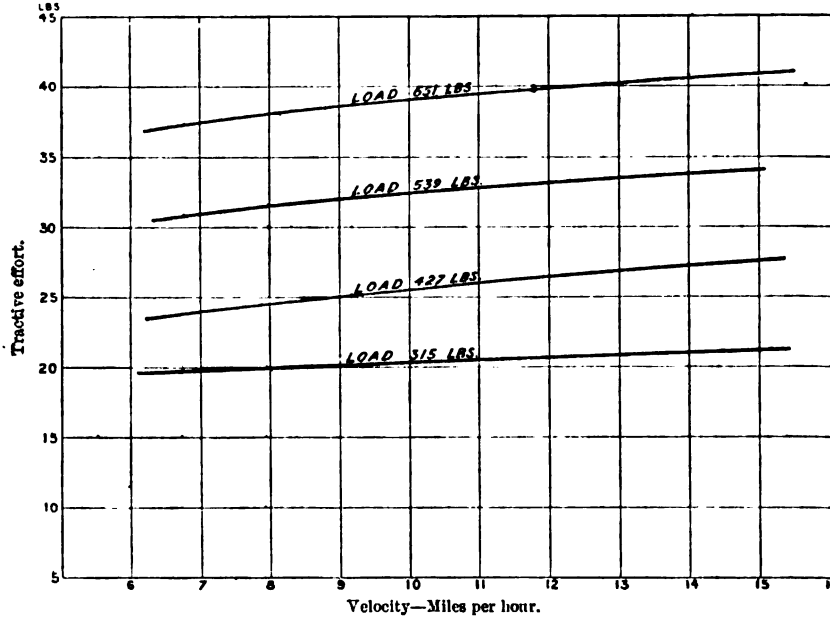
plotted between tractive effort per ton and velocity (fig. 3) which is useful for comparison with similar curves for wheels of different diameters.

Additional experiments were made on pneumatic tyres under the auspices of the Automobile Club of Great Britain and Ireland. For these trials it was found that the car used by the Committee was not of sufficient power ; a 24 horse-power Panhard and Levassor car was therefore temporarily used.

It will be noticed in the photograph of this later car (fig. 6, Plate XI.) that the springs supporting the experimental wheel have been placed above the frame, thus enabling the centre of gravity of the trailer to be brought very near to the ground. This alteration was found necessary owing to a sidelong oscillation taking place at high velocities when the frame was in the position as first arranged. The altered position proved quite

FIG. 2.—Tractive-effort Velocity Curves for 24" × 2¼" Pneumatic Tyre on Macadam.



successful, not the slightest oscillation of the trailer being noticed even when heavily loaded and travelling at 35 miles per hour, which, it must be admitted, is a fairly high speed at which to tow a wheel loaded with a weight of 900 lb.

Some difficulty was at first experienced in getting this car to pull steadily at lower speeds, as the governor was constantly coming into action owing to the full power not being required. This was finally overcome by completely cutting out two of the cylinders, and thus reducing the power of the car by half.

These experiments were made with two sizes of tyres, one 34 inches diameter by 3½ inches, and the other 34 inches diameter with a mean diameter of cross-section of 4½ inches.

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FIG. 6.—Photograph of Panhard and Levassor Car, with Dynamometer attached.

Illustrating the Report on the Resistance of Road Vehicles to Traction.

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Runs were made at speeds of from 12 miles to 35 miles per hour, over both good macadam, frozen hard, and good dry setts. The springs supporting the trailer were 3 feet 2 inches long, each having four plates $2\frac{1}{4}$ inches by $\frac{5}{16}$ inch, and the tyres were in all cases pumped to a pressure of 60 lbs. per square inch, the total load on the wheel being 896 lbs. The results obtained and plotted in fig. 4 show that the tractive effort under similar conditions as to road surface and speed is less for the tyre of smaller cross-section than it is for that having the larger section. This may be due to the fact that the tread of the larger tyre was much thicker than the smaller, rendering it in consequence more after the nature of a solid tyre, it being well understood that a perfect pneumatic tyre should have as little inelastic, or comparatively inelastic, material about it as possible; or, the greater tractive effort may have been due to the greater cross-section. Repeated experiments alone can definitely settle this question.

FIG. 3.—Curve showing Tractive Effort per ton for Pneumatic Tyre 24" × $2\frac{3}{4}$" on Macadam.

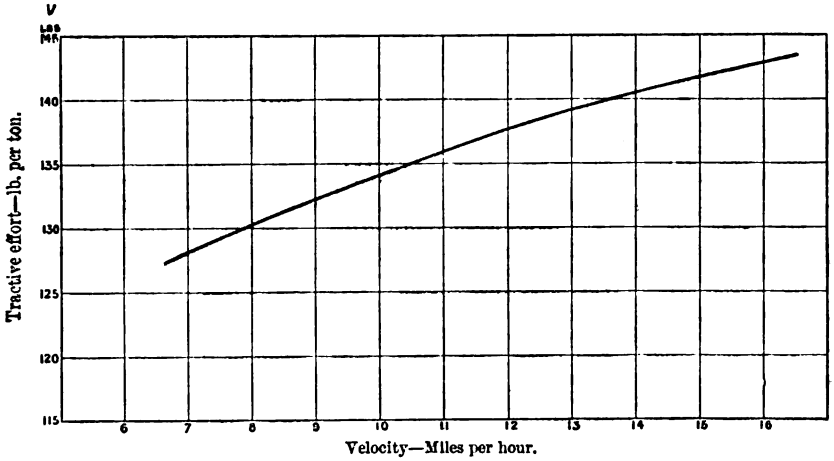

Fig. 5 shows these curves plotted as tractive effort per ton. On the same axes the tractive effort per ton has been plotted for the previous wheel (pneumatic tyre 34 inches by $2\frac{3}{4}$ inches), and it is very much greater than that for the 34-inch wheels.

This Committee is not yet in a position to state the exact relation between tractive effort and diameter of wheel; but, taking the results of General Morin, that the draught is inversely proportional to the diameter of the wheel, a curve has been plotted (fig. 5) which reduces the tractive effort of the 24-inch wheel to that of an equivalent 34-inch wheel. Considering the variations that may have existed in the roads on which the wheels were tried, as it was at different times of the year, these results harmonise fairly well.

II. *Suggestions by Mr. B. J. Diplock.*

The following suggestions with regard to trials of wheels for heavy traffic were submitted to the Committee by Mr. B. J. Diplock (member)

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FIG. 4.—Tractive-effort Curves for 34″ Pneumatic Tyres on New Macadam.

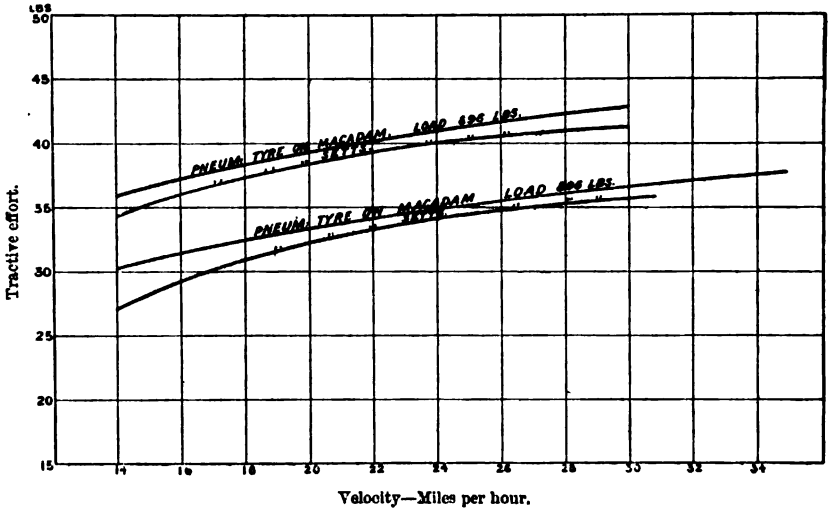
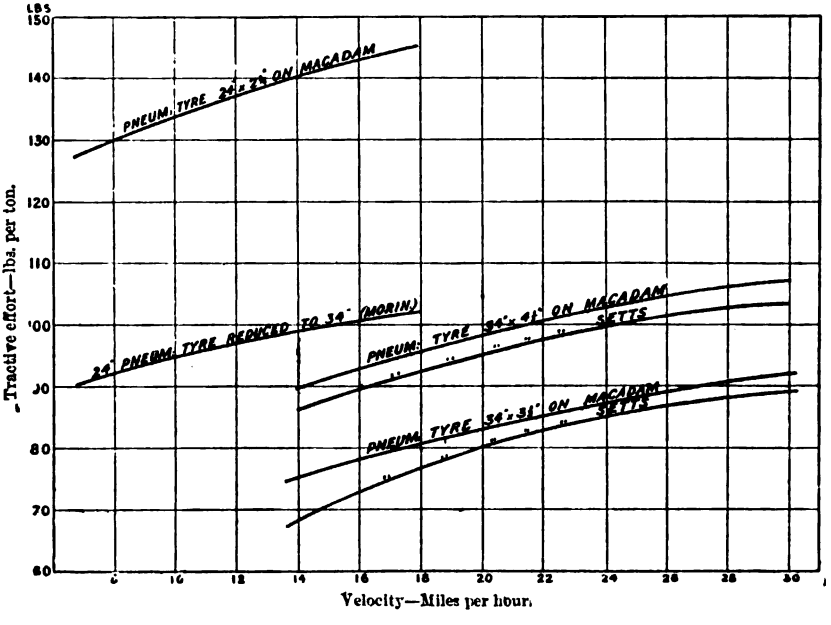


FIG. 5.—Curves showing Tractive Efforts per ton for Pneumatic Tyres.

(NOTE.—The macadam on which the 24″ wheel was run was older than that on which the 34″ wheels were tried.)



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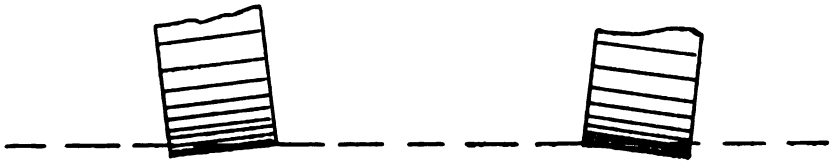
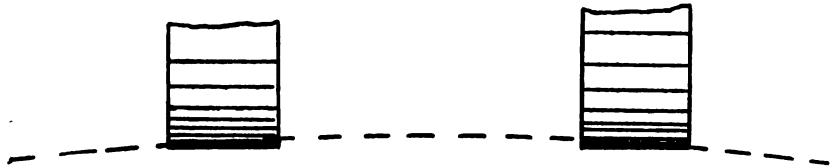
at a meeting held at the Society of Arts, London, on Friday, May 15, 1903 :—

Assuming that :

1. All wheels are coned or straight in cross-section ;
2. All roads are arched or flat in cross-section ;
3. It seems evident that coned wheels on flat roads, thus—



or flat wheels on arched roads, thus—



cause increased road resistance in proportion as the wheels are coned or the roads arched in relation to each other, and that the same result is caused by inequalities in the road surface—viz., that wide tyres do *not* obtain an even bearing throughout their entire width, except on very soft and yielding ground.

Starting from the above statements, and as the results of long experience and observation, he had come to the conclusion that for *heavy* traffic wheel tyres of *more* than, say, 9 inches in width have, in practice little or no material value as tending to reduce road resistance or damage to the road surface, and he suggested that experiments might be carried out with a view to testing the accuracy of this conclusion.

Assuming that 9 inches were adopted as a useful maximum width of tyre for heavy haulage on average roads, he submitted the following theory :—

1. That the supporting power of a road is limited by the cohesive friction of the road molecules or particles against each other.

2. That this supporting power limit varies very considerably according to the material used in constructing the road and the moisture absorbed in the road.

He would be prepared to find that road resistance up to certain limits of weight on each wheel (for each class of road) varies approximately in direct proportion to the increased weight on each wheel.

He was of opinion, however, that if this limit of weight per wheel is exceeded so as to overcome the frictional cohesion of the road molecules against each other, then an entirely new set of conditions arises ; and he would be prepared to find that road resistance would, under such conditions, increase altogether *out* of proportion to increased weight on the wheels.

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He urges that the Committee take steps to ascertain—

1. The maximum 'useful' width of tyre for *heavy* traffic on average roads.

2. The 'limit' of weight on each wheel (for various classes of road) up to which road resistance increases in direct approximate proportion to the increase of weight on each wheel.

3. The rate of increased road resistance when that limit is *moderately* exceeded.

III.—*Papers read at the International Congress on Automobilism, Paris*, 1903.

By permission of the British Association Committee a paper was read at the Congress by Professor Hele-Shaw on the work which has been carried out during the past year.

He gave a description of the British Association dynamometer, recounting the reasons why it was decided to adopt the one-wheel trailer, and then gave a *résumé* of the experiments which have been made. The paper was illustrated by photographs and diagrams.

Abstract of Paper by M. GERARD LAVERGNE, *on Tractional Resistance:—Tractive Effort—Springs—Effect of Nature of Tyre—Air Resistance—Power required by Automobiles.*

Tractive Effort.

In his paper M. Lavergne referred to the Report of this Committee read at the Belfast meeeting last year, and gave some particulars of similar experiments made in America. He stated that Professor Ira O. Baker, of the Illinois State University, is of opinion that the axle friction is independent of the speed, but varies inversely as the square root of the load supported. Where the vehicles carried only a light load, the coefficient of friction was about 0·02; heavy loads gave an average of not more than 0·015, while with exceptionally heavy loads this coefficient fell as low as 0·012. These values assume efficient lubrication; with indifferent lubrication they rose to as much as six times the amount.

Concerning rolling friction Professor Baker believes that the resistance varies inversely as the square root of the diameter of the wheels.

The values above given for axle friction differ somewhat from those given by M. Forestier, who gives 0·10 for an ordinary bearing lubricated with cart grease, 0·01 with patent axle-box lubricated with oil, 0·005 with lubricated ball-bearings, 0·0025 with the lubricated 'Philippe' bearings (which last-named are ball-bearings having small balls between the larger ones, thus obviating friction amongst the latter and ensuring an equal distribution of pressure upon all the balls).

To thoroughly understand the difference between these sets of figures it would be necessary to know the exact conditions of lubrication and the nature of the bearings employed by Professor Baker.

M. Lavergne does not consider that the differences shown are very surprising, as we know that the coefficient mentioned by M. Forestier has reference to a patent journal, the wheel revolving evenly in a plane, without lateral jerks, whilst a wheel revolving in less favourable conditions—as, for instance, on a rough paved road—would give a higher figure. The most important fact shown by Professor Baker's experiment is that the friction of the journal varies with the load upon the axle.

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M. Jeantaud made some experiments on road resistance with an electric vehicle. Such an automobile is eminently suited for this work, on account of the perfect sensibility and absolute accuracy obtainable. He used for these experiments a car having four equal wheels fitted with Michelin tyres 840 by 90 mm. ; the front axles were 40·0 mm. diameter and the back axles were of tempered steel on bronze hubs, the diameter being 55·0 mm. The car with four persons weighed 1,780 kilos., or 3,925 lbs.

At a speed of 15 kilometres per hour, or 9·32 miles per hour, this car required a current of 22 amperes at 80 volts—that is, 1,760 watts.

If 15 per cent. is deducted as the friction of the motor itself, the energy of propulsion is 1,496·0 watts, or 149·6 kilogrammetres per second.

Working this out in English units, we have a total tractive effort of 81 lbs., or 46 lbs. per ton.

M. Jeantaud has calculated with Morin's formulæ and coefficients.

First.—The rolling friction, by the formula,

$$F_r = f \frac{P}{D},$$

in which f is a coefficient expressed in kilogrammes, varying with the nature of the road and the width of the tyre, the value of f for a smooth dry road being 0·010 ; F_r is the rolling friction ; P is the total load on the vehicle in tons ; and D is the diameter of the wheel.

Second.—The axle friction by the formulæ,

$$F_a = s \frac{d}{D} p,$$

in which s is a coefficient expressed in kilogrammes (varying with the mode of lubrication and the nature of the rubbing surfaces) and being taken as equal to 0·015.

d is the diameter of the axle, and p the weight of the car without the wheels.

Adding these two resistances and multiplying the total effort by 4·16, the velocity in metres per second corresponding to 15 kilometres per hour, the work done per second is 182·274 kilogrammetres, or 1,320 ft. lb.

This figure would be that given for an iron-tyred vehicle, the only kind employed at the time of M. Morin. According to M. Michelin, the advantage obtained by using pneumatic tyres over iron tyres on a road similar to the above would be at least 15 per cent. Taking 15 per cent. off the figure obtained, the work expended on traction is reduced to 154·933 kilogrammetres, or 1,120 ft. lb. per second. This value is very near to that actually obtained, viz. 1496 kilogrammetres per second (1,084 ft. lb. per second), and this proves the correctness of the values given for the coefficients f and s.

In January 1903 M. Jeantaud, with the same electric automobile, between the bridges of Bineau and Neuilly, on a stretch of road just 1 kilometre in length, showed that the tractive effort for a road covered with thick mud was, as General Morin found, quite double that on a dry road.

On January 20, on the road in question, being then very muddy, the track was covered on the third speed in 4 minutes, with a current of 30 amperes at 80 volts. In English units this would be a mean speed of 9·32 miles per hour or 13·66 feet per second, with a total tractive effort of 130 lbs., or 74 lbs. per ton.

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On January 21, over the same kilometre, hardened by the frost and very smooth, on the third speed the track was covered in 3 minutes 28 seconds with a current of 20 amperes at 80 volts. This speed would be equivalent to 10·80 miles per hour or 15·80 feet per second, with a total tractive effort of 75 lb., or 42·7 lb. per ton.

Thus the tractive effort was 42·3 per cent. less on the hard road than on the muddy road at the third speed. On the fourth speed M. Jeantaud found that this difference increased to 50 per cent.

These experiments confirm those of General Morin and show the accuracy with which that ingenious man carried out his work. But they have to be made at speeds near to those used by Morin, and it is not at all certain that other experiments, at much higher speeds, under the new conditions of automobilism, so different from those of the iron-tyred vehicles, would give corresponding results.

Springs.

When pneumatic tyres are used, it must not be thought that springs can be dispensed with, as the duty performed by the tyre is quite different from that of the springs. The pneumatic tyre does away with the slight vibration caused by the wheel encountering gravel, stones, and small obstacles generally, but the height of the axle from the ground scarcely varies, as the tyre absorbs within itself these small objects.

Experience has proved that these small vibrations, if not absorbed by the tyre, would be transmitted through the springs to the body of the car to the great discomfort of its occupants, and would tend to reduce the life of the motor, owing to the crystallisation of the parts subjected to strain.

But the pneumatic tyre will not yield much more than 1 inch, and is in consequence unable to save the car from vibration when passing over a large obstacle or a deep rut; whereas the springs, with a resilience of, say, 4 inches, would be well adapted for this purpose.

Spiral springs have been tried with unsatisfactory results, and they can practically only be used where heavy weights are carried. Plate springs must necessarily be employed when ease and comfort are desired.

It may be pointed out here that the method of attaching plate springs to the frame is a matter of considerable importance. M. Gaillardet believes that the usual method is not at all satisfactory. The ordinary practice is to use clips which are pivoted to a bracket depending from the frame, these clips being outside of and lower than the normal plane of the spring. From the bracket they rise at an angle of about 45° and meet the ends of the spring to which their upper ends are pivoted. The result is, when the wheel passes over an obstruction of any appreciable size, the axle rises under the centre of the spring, the plates of which lengthen (theoretically) and tend to form a straight line, and at once the load above is thrown upward in the same proportion.

On the other hand, where the clips are so connected with the spring as to work within its length and under its ends, instead of beyond them, any shock given to the wheel causes the load to fall, and the loss of mechanical energy is less.

M. Gaillardet is of opinion that the springs should be so arranged that each wheel is free to rise or fall independently of the others. When this is done, an obstacle under one wheel will raise that wheel only, and the centre of gravity of the whole car is raised a smaller distance than would otherwise be the case. To attain this result he proposes to mount

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the front axle on a single transverse spring, thus reducing the number of springs on the car to three.

When the springs have been depressed by an obstacle in the roadway, they only return to the position of equilibrium after a number of oscillations of decreasing amplitude have taken place. It is advisable to spare the vehicle this continued oscillation, as at high speeds it causes the wheels to leave the ground, and consequently reduces the effective power of the motor. M. Truffault has taken out a patent for an arrangement to remedy this defect. The friction between two metal surfaces prevents the oscillations from arising. He tried a spring fitted with this damping action on a quadricycle, which carried his son to victory over the kilometre at Deauville in 1901. This spring has given very good results, enabling one to travel rapidly even over the worst of paved roads.

Effect of the Nature of the Tyres.

The experiments of M. Michelin have shown that the tractional resistance is reduced from 15 per cent. to 30 per cent., according to the nature of the road, by the use of pneumatic tyres in place of metal tyres. He explains this by the well-known saying, 'Le pneu boit l'obstacle.' Baron de Mauni in a recent work has given an account of some experiments which he made on different tyres, particularly pneumatics. He showed that if two wheels with tyres of equal widths supported equal loads, the one that has the greater arc of contact with the ground will travel better than the other. With a rigid tyre such extended contact can only be secured by increasing the diameter of the wheel, which is impossible beyond certain limits, so that the tyre will sink into the ground by an amount proportional to the weight carried. With rubber tyres the increased area of contact is due to the elasticity of the material and not to the increased diameter, so that the wheel does not sink into the road.

Professor Baker's experiments seem to show that on good roads the width of tyre has little effect on the resistance, and that even on bad roads the advantage lies sometimes with the wide tyres and sometimes with the narrow ones, according to circumstances. Arguments have been advanced in favour of both wide and narrow tyres, but nothing very definite seems to be known on the subject; according to M. Michelin, if we reduce the width of the tyre we reduce the adhesion to the ground, which is already little enough. As a case in point, he mentions that M. Serpollet, in order to attain a speed of 120 kilometres (75 miles) per hour on the Promenade des Anglais in 1902, had to deflate his tyres, and thus get a larger surface of contact with the ground. Besides, in order to get a narrow tread it is necessary to give to the tyre a form other than circular, and this shape can only be retained at the expense of its flexibility. Consequently a tyre of this description will be subjected to greater internal friction in its fabric than one naturally circular in section, and the energy wasted will be therefore greater.

The whole question, however, is very much open to discussion, and the present Congress may offer to the opposing schools an opportunity of coming to some understanding.

Resistance of the Air.—Study of Forms to diminish this Resistance.

The air resistance is a retarding force of the highest importance, especially where speed is concerned, and there is unfortunately great

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uncertainty both as to the formulæ to be applied, and the values of the coefficients which appear in them.

The best known formula is

$$R = KSV^2$$

in which R equals resistance in kilogrammes.

S equals projected area in square metres of total surface of vehicle on a plane normal to direction of motion.

V equals velocity in metres per second.

K a numerical co-efficient which varies between very wide limits according to the form and the speed of the vehicle.

The formula by M. Desdouits, $R = KV$, is sometimes preferred, as it is more correct for high speeds.

The different values given to K in the first formula may be due to the varied conditions under which the experiments were made.

Signor Canovetti had made some experiments at Zossen to determine the value of K. He had a copper wire, 380 metres long, stretched between the summit of the fortifications at Brescia and a point in the plain, about 70 metres below. Along this wire different surfaces were allowed to descend freely. A circle, with a surface of ·073 square metres, moving with a velocity of 12 metres per second, gave a resistance of 84 grammes. The same circle, having a spherical cap in front, offered a resistance of only 21 grammes. When this hemisphere was followed by a cone, whose height was five times its diameter, the resistance fell to 13 grammes, or one-sixth of that of the plane circle. With this same solid, turned the other way about—that is, with the apex of the cone towards the direction of motion—the resistance rose to 18 grammes.

Signor Canovetti has recognised that a rectangular surface, placed with its long sides horizontal, offers a sensibly greater resistance to the air than when its short sides are horizontal. His experiments seem to show that the coefficient K diminishes somewhat as the speed increases, but investigations carried out at Zossen point to the conclusion that the resistance may increase tenfold when the velocity is only tripled. It is thus clear that air resistance is a matter of no small importance when speeds up to 60 or 80 miles an hour are attained. At 85 kilometres (53 miles) per hour, the energy required to overcome the air resistance on a vehicle, with an opposing surface of 1 square metre (1,550 square inches), may be 7, 11, or 20 horse-power, according to the coefficient K given as 0·0288, 0·0648, or 0·116 by MM. Forestier, Bourlet, or Thibault.

The question then arises, What is the best shape for a car? The answer depends on several things—as, for example, the necessity of placing the radiator in such a position that it may be efficiently cooled by the air rushing through it. Only general principles may be laid down. The front of the car ought to taper, and the back be more pointed still, like the form of a fish: transverse rectangular surfaces that cannot be dispensed with, should, as far as possible, have the longer sides vertical; and it is well to have doors on the car to prevent the air from rushing in between the dashboard and the seat.

These conditions are quite neglected in most of the present-day cars. Particularly is this the case in the 'Coffin Head,' that unlovely affair so much in vogue—a flat surface directly opposed to the air pressure. With a radiator of the honeycomb type, a transverse position is necessary for

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cooling purposes, and Signor Canovetti has shown evidence that a perforated surface will offer less resistance to the air than a plane one of similar area. This is not of much advantage with an automobile as the air, after having passed through the holes in the radiator, meets with further obstacles in the mechanism inside the hood.

With regard to the working parts situated under the car, these should be made by the aid of inclined planes to cut the air rather than oppose it.

M. Lavergne commends the suggestion of M. Forestier that different-shaped bodies should be mounted on an electric chassis, and the total resistance of chassis and body accurately measured, so that a really practical model could be designed.

Power required by Automobiles.

Under this heading M. Lavergne has shown the enormous reduction of weight per horse-power that has taken place during the last eight years. In 1895, Levassor made the run from Paris to Bordeaux in a 4 horse-power car weighing about 1 ton, or 1 horse-power per 550 lb. dead weight. In 1896 this weight was reduced to 365 lb. per horse-power; in 1900 it fell to 90 lb. per horse-power. In the recent Paris-Madrid race M. Gobron Brillie appeared with a 100 horse-power car, the weight of which represented only 22 lb. per horse-power. This weight has been still further reduced in the case of motor bicycles, reaching as low a figure as 17·5 lb. per horse-power.

But there is not a corresponding increase in speed. In 1901 M. Fournier made over 53 miles per hour with a 28 horse-power Mors; last year M. de Knyff only slightly exceeded 58½ miles per hour with a 70 horse-power motor; that is, an additional 40 horse-power.

To what must this relatively small increase of speed be attributed? Air resistance is responsible for some increase but certainly not all.

An extremely powerful motor must be accompanied by a comparatively heavy load, otherwise the wheels do not 'bite' well and energy is wasted. It is well known that the modern racing-car skims along the surface of the course, without sufficiently close contact between the wheels and the ground; in any case driving wheels should be more heavily weighted and springs made less elastic. To reduce the power lost in vibration, the engine should be more perfectly balanced, and, if necessary, the fly-wheel and motor itself made heavier. 'Who shall say,' M. Lavergne concludes, 'whether, instead of building very powerful yet extremely light motors—the durability of which is questionable—it would not be better to rest content with a vehicle of smaller power, and use it more effectively?'

IV. *Negotiations with the War Office.*

At a Committee Meeting held at the Society of Arts on May 15, 1903, it was proposed that as the expenses of this research were extremely heavy it would be advisable to approach the Mechanical Transport Committee of the War Office, in order to see if they would conduct the experiments with heavy traction, as they had at their command various powerful motors and traction engines, together with the necessary variety of wheels. The Transport Committee in return would have the use of the British Association recording instruments for their own experiments.

This British Association Committee would have access to the information obtained which was of a scientific character with a view to

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publication, but it would not concern itself with data relating to the actual waggons and other matters of a purely military character.

As a result the Transport Committee replied favourably, and arrangements, it is hoped, will now be made by which important work will be carried on by that Committee, thereby avoiding the very heavy expense to meet which it is difficult to raise funds from private sources.

Small Screw Gauge.—Report of the Committee, consisting of Sir W. H. PREECE (*Chairman*), W. A. PRICE (*Secretary*), Lord KELVIN, Sir F. J. BRAMWELL, Sir H. TRUEMAN WOOD, Major-Gen. WEBBER, Col. WATKIN, Lieut.-Col. CROMPTON, A. STROH, A. LE NEVE FOSTER, C. J. HEWITT, G. K. B. ELPHINSTONE, E. RIGG, C. V. BOYS, J. MARSHALL GORHAM, O. P. CLEMENTS, W. TAYLOR, Dr. R. T. GLAZEBROOK, *and* MARK BARR, *appointed to consider means by which Practical Effect can be given to the introduction of the Screw Gauge proposed by the Association in* 1884.

THIS Committee was originally appointed at the York meeting of the British Association in 1881, and, after considerable labour, they made their final report at the Montreal meeting in 1884, recommending a very useful series of small screws, which were very generally adopted for watch and electrical apparatus. At the Ipswich meeting of the British Association in 1895 the Committee was reappointed to consider complaints that screws of the British Association thread proposed by the Committee in 1884 were not interchangeable. It appeared to the Committee that the difficulty arose from want of some ready means of constructing gauges for testing the screw thread, and they endeavoured, during the years 1896–9, to remedy this by the construction of a series of such gauges. The edges of the thread, as is well known, are rounded at the crests and roots, and great difficulty was experienced in obtaining satisfactory gauges for such a form, while it was stated that a flat-topped thread could be accurately made, and gauged with comparative ease. At the Dover meeting, in 1899, this Committee reported recommending that they should be reappointed for the purpose of considering whether the British Association form of thread for small screws should be modified. This recommendation was adopted, and as a result the Committee reported at the Bradford meeting, in 1900, that it was desirable to replace the present form of screws from No. 0 to No. 11, by one having a flat top and bottom to the thread. It was pointed out that in the belief of the Committee such screws would, owing to the inevitable rounding at the edges, be interchangeable with the old stock in the majority of cases, and that only where great care had been taken to work closely to the old standard would any difference be noticed, so that practically while the B.A. small screw *gauge* had a flat-topped thread, the B.A. *screws* would still have rounded tops and bottoms. After making recommendations to the above effect the Committee was reappointed to obtain a set of the proposed screws, with tools and gauges for a comparison with the present ones. Additional members were added, and new light was thrown on the matter by their assistance. On the one hand, it appears that gauges can be constructed readily and accurately only if the thread be flat topped. On the other, that screws made with any ordinary form of screwing tackle will have round tops, but that the form of these tops will vary and may vary to such an extent as to prevent the inter-

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changeability of the screws. The resolution of 1900, modifying the form of the thread, was intended to apply to the gauges only, and it was supposed that the roots and crests of the thread in screws formed by dies or in nuts formed by taps would still be rounded, and the form of the thread would thus approximate very closely to that of the Montreal definitions. However, in view of the facts which have been put before them, the Committee now think it best to state explicitly that they do not propose to alter the form of the B.A. screw thread, and that they desire to withdraw the recommendation accepted at Bradford in 1900.

The original form of the British Association screw thread was laid down in the Montreal Report, 1884, to the following effect, viz. :

The angle of the thread was defined to be 47·5°.

The values of the pitches and of the external diameters of the screws were scheduled in millimetres ; the depth of the thread was defined to be sixteenths of the pitch, and the radius of the rounding was to be the same at root and crest. The radius of the rounding was very nearly two-elevenths of the pitch by this rule.

This definition, closely adhered to, led to inconveniently small fractions in those quantities which had to be calculated from the scheduled dimensions, but this may be avoided if we replace the definition by an equivalent schedule of dimensions of all parts from which the insignificant figures are omitted.

Retaining the angle of 47·5° in all cases, we adopt the following schedule :

British Association Screws.

SCHEDULE I.—*Schedule of dimensions in millimetres.*

Designating Number	Pitch P	Outside diameter D	Effective diameter E	Core diameter C	Depth of Thread d
0	1·0	6·0	5·4	4·8	·6
1	·9	5·3	4·76	4·22	·54
2	·81	4·7	4·215	3·73	·485
3	·73	4·1	3·66	3·22	·44
4	·66	3·6	3 205	2·81	·395
5	·59	3·2	2·845	2·49	·355
6	·53	2·8	2·48	2·16	·32
7	·48	2·5	2·21	1·92	·29
8	·43	2·2	1·94	1·68	·26
9	·39	1·9	1·665	1·43	·235
10	·35	1·7	1·49	1·28	·21
11	·31	1·5	1 315	1·13	·185
12	·28	1·3	1·13	·96	·17
13	·25	1·2	1·05	·90	·15
14	·23	1·0	·86	·72	·14
15	·21	·9	·775	·65	·125
16	·19	·79	·675	·56	·115
17	·17	·70	·6	·50	·10
18	·15	·62	·53	·44	·09
19	·14	·54	·455	·37	·085
20	·12	·48	41	·34	·07
21	·11	·42	·355	·29	·065
22	·10	·37	·31	·25	·06
23	·09	·33	·275	·22	·055
24	·08	·29	·24	·19	·05
25	·07	·25	·21	·17	·04

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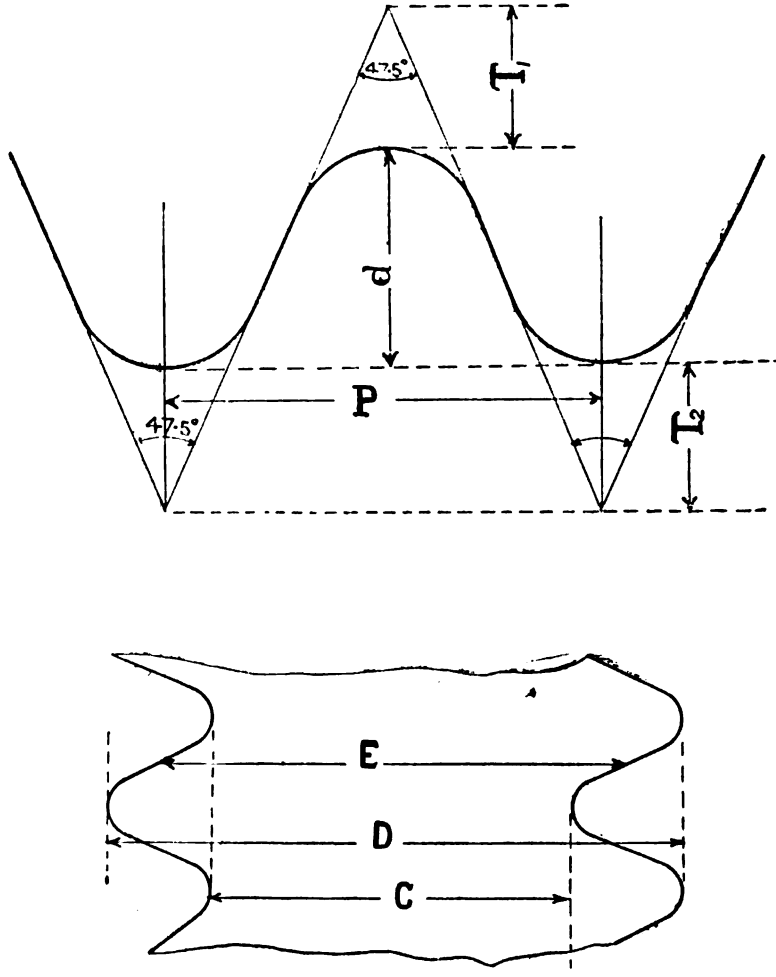
In all cases the length of bearing surface on the sides of the screw must not be reduced below that given by the standard form of screw.

In Schedule I. the effective diameter is a mean of the outside and core

FIG. 1.



diameters, and the dimensions figured T_1 T_2 in fig. 1 (called truncations) are equal to each other. The values of T_1 T_2 are tabulated in Schedule II.

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SCHEDULE II.—*Schedule of truncations of normal threads in millimetres.*

Number	Truncation	Number	Truncation
0	·268	13	·067
1	·241	14	·061
2	·218	15	·057
3	195	16	·051
4	·178	17	·047
5	·158	18	·040
6	·141	19	·037
7	·128	20	·033
8	·114	21	·030
9	·104	22	·027
10	·094	23	·024
11	·084	24	·021
12	·074	25	·020

For the convenience of English measurement, the nearest equivalents of the pitches and diameters of screws in thousandths of an inch are given in Schedule III.

SCHEDULE III.—*Schedule of approximate dimensions in thousandths of an inch.*

Number	Pitch	Diameter	Number	Pitch	Diameter
0	39·4	236	13	9·8	47
1	35·4	209	14	9·1	39
2	31·9	185	15	8·3	35
3	28·7	161	16	7·5	31
4	26·0	142	17	6·7	28
5	23·2	126	18	5·9	24
6	20·9	110	19	5·5	21
7	18·9	98	20	4·7	19
8	16·9	87	21	4·3	17
9	15·4	75	22	3·9	15
10	13·8	67	23	3·5	13
11	12·2	59	24	3·1	11
12	11·0	51	25	2·8	10

In practice interchangeability has been to some extent secured by allowing clearances at the root and crest of the thread. The Committee think it desirable to suggest the amount of these clearances in the gauges, and they have agreed :

(*a*) That clearance should be provided at the root of the thread of the screws, and should be obtained by cutting the thread of the screw deeper than the normal, thereby reducing the diameter of the core ;

(*b*) That clearance may be provided at the crest of the thread of the screw, and should be obtained by the use of a tap whose outside diameter is greater than the normal ;

(*c*) That the limits of these clearances be defined by the figures of Schedule IV.

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SCHEDULE IV.—*Schedule of maximum and minimum diameters of the cores of screws, and of the outside diameters of taps, where clearance is provided.*

Designating Number	Cores of Screws		Outside diameters of taps	
	Maximum	Minimum	Maximum	Minimum
0	4·74	4·6	6·2	6·06
1	4·16	4·04	5·48	5·36
2	3·68	3·57	4·86	4·75
3	3·17	3·07	4·25	4·15
4	2·77	2·68	3·77	3·64
5	2·45	2·37	3·32	3·24
6	2·13	2·05	2·91	2·83
7	1·89	1·82	2·60	2·53
8	1·65	1·59	2·29	2·23
9	1·41	1·35	1·98	1·92
10	1·26	1·21	1·77	1·72
11	1·11	1·07	1·56	1·52
12	·94	·9	1·36	1·32
13	·88	·85	1·25	1·22
14	·71	·67	1·05	1·01
15	·64	·61	·94	·91
16	·55	·52	·83	·80
17	·49	·47	·73	·71
18	·43	·41	·65	·63
19	·36	·34	·57	·55
20	·33	·32	·50	·49
21	·28	·27	·44	·43
22	·24	·23	·39	·38
23	·21	·20	·35	·34
24	·18	·17	·31	·30
25	·16	·15	·27	·26

If clearances up to the amount indicated in Schedule IV. be generally adopted by makers, interchangeability will, in the opinion of the Committee, be thereby promoted; and the Committee recommend that, except in the case of screws made for special cases, the above clearances in the core and outside diameters of the screws be adopted as normal.

As appears from the above considerations, for many purposes the Committee do not attach great importance to the exact form of the thread at the crest and root.

While adhering then to the form of the thread as laid down in the Montreal Report, and in Schedule I. above, they would advise the acceptance as B.A. screws of all screws which pass the nut gauge (1) described below and have the requisite core and outside diameters, and of which the straight portions of the sides are not less than those of the standard screw.

The Committee have given a very long time to the consideration of various forms of gauges. As appears from their earlier reports, it is clear that the difficulty of constructing gauges with rounded crests and roots has not been overcome, and the Committee are reluctantly compelled to relinquish the task of making gauges of the ideal B.A. form following the outline A, B, C, D, E, F, G, H, K (fig. 2). Two possible forms of flat-topped gauges for screws have been considered: (1) a gauge following the outline A, C, N, O, G, K; (2) a gauge following the outline A, L, M, N, O, P, Q, K. With regard to (1) it is clear that while it will test the pitch and the

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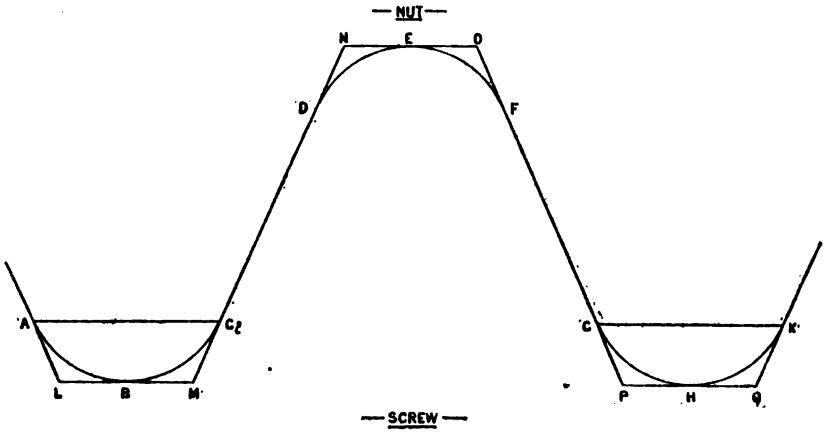
effective diameter, it will not gauge the root of the thread, and will not therefore separate screws which are interchangeable with a standard nut from those which are not. Besides testing a screw with a nut gauge of this form, it will be necessary to test its core diameter by means of a gap or notch gauge. If the screw pass the nut gauge, and have at its root the clearance recommended, it is practically certain it will be interchangeable with a nut of standard form. A screw which passes this gauge and has the requisite diameters as given in Tables I. and II. at the core and outside, and the requisite bearing surface, may be called a B.A. screw.

The other form of flat-topped gauge which has been considered follows the outline A, L, M, N, O, P, Q, K. A gauge of this form will test the minimum diameter, as well as the pitch and effective diameter of screws, and all screws which pass it are interchangeable with the standard nut. Moreover, in view of the clearance recommended at the root, the Committee anticipate that in practice this gauge could be usefully employed. At the same time it is clear that it will not pass a screw any part of which lies above the lines L M, P Q, and that it would therefore reject a screw having the standard form.

FIG. 2.



Thus in conclusion the Committee recommend :

I. That the form of the standard B.A. thread be that defined at the Montreal meeting in 1884, and which follows the outline A, B, C, D, E, F, G, H, K of fig. 2.

II. That the form of the B.A. gauge for screws be that defined by the outline A, C, N, O, G, K, and that this be used with a gap or notch gauge, as described in the report.

III. That the dimensions of the notch gauge be such as to ensure that the core diameters lie between the limits given by Schedule IV.

IV. That a screw which passes the B.A. gauge, and of which the core and outside diameters are given by Table II. and Table I. respectively, be accepted as a B.A. screw, provided that the length of the

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bearing surface is not reduced below the length corresponding to D, C in fig. 2.

A machine has been made, under the superintendence of the Committee, by the Cambridge Scientific Instrument Company, for the accurate measurement of screw gauges. A description of this is given in the Appendix. The machine has been placed in charge of the Committee of the National Physical Laboratory, and the Director of that Institution is prepared to undertake the measurement of gauges and screws submitted for examination.

The Committee have further to report that the Engineering Standards Committee have appointed an influential sub-committee to deal with the standardisation of gauges of all kinds, including screw gauges, and that in their opinion the work which they have been doing may with advantage be left to this committee and to the National Physical Laboratory to carry on. The Committee have not considered in detail the question of the limits of error in screws purporting to represent the B.A. thread. This matter they think it desirable to leave to the Engineering Standards Committee, who will be able to discuss it in connection with larger screws and gauges. On the other matters submitted to them they do not wish to report further. In consequence they present this as their final report, and do not ask for reappointment.

We, the undersigned members of the Small Screw Gauge Committee, do not accept in its entirety the above report, as we consider that some of the recommendations contained in it are not those held by the whole of the Committee.

1. The report appears to explicitly restore without modification the form of the original B.A. thread as defined in the Montreal Report.

2. It provides gauges for testing threads of a form differing from those laid down in the earlier part of the same report.

The work of the first three years of this Committee showed that the difficulty in constructing tools and gauges of the B.A. thread was at the root of the inaccuracy complained of in commercial screws. On that ground the Committee asked for an extended reference, and recommended a new form of thread. The construction of taps for the old thread requires exceptional manipulative skill, and does not admit of great exactness. An average tool maker can produce taps of the new thread without difficulty, and the process admits of extreme refinement. Moreover, since the manufacture both of gauges and of screwing tools alike depends upon the construction of accurate taps, the adoption of a form of thread which is easily produced met at once the difficulties of the screwing tools, and of gauges or trial pieces for testing screws when made.

The present report from which we dissent confirms the recommendation of this form of thread for the gauges, but withdraws it from screws, notwithstanding that on account of the number used the simplification in the construction of taps is more valuable in the case of those for screwing tools than in those for gauges.

Although we admit the fact that screws made in dies or in screwing

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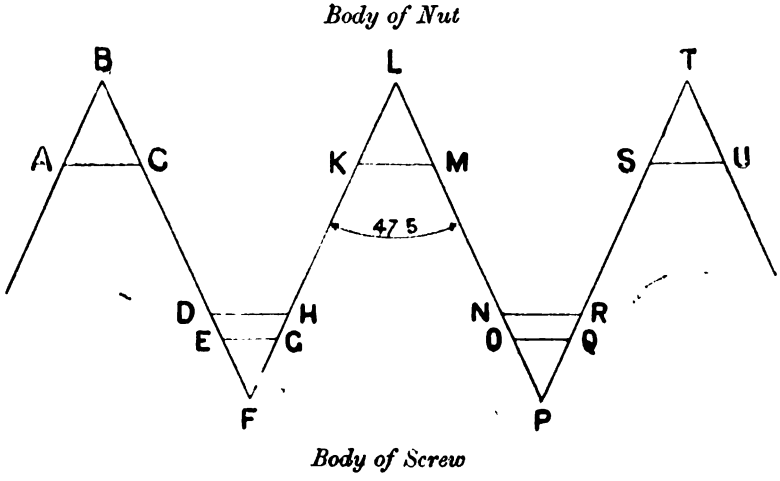
machines will have some rounding at the crests and roots of the threads, we believe that we can secure the objects for which this Committee was appointed in 1895, viz., to produce in a material form gauges which could be checked by a central authority, such as the Board of Trade or the National Physical Laboratory, and certified copies of which could be issued to manufacturers and buyers of screws to secure commercial interchangeability.

We recommend, therefore, with reference to threads Nos. 0–11 :—

1. That sets of gauges should be made and verified, each set consisting of six pieces as follows, A–F.

A. A male gauge screw of the pitch and effective diameter laid down for the distinguishing number in Schedule I., the thread having a V-shaped

FIG. 3.



root, and a crest flattened cylindrically to the over-all diameter laid down in the table. The outline of the thread is in fig. 3, A C F K M P S U.

This piece A is for the purpose of testing nuts and nut gauges to check the correctness of the pitch, angle of thread, effective diameter, and root diameter, and for checking the hole gauge E.

B. A tap, a copy of A in all respects, except that it is fluted and backed off as a tap, and that the crests are left nearly approaching the sharp V form as is possible, so as to maintain a cutting edge with this angle of thread, *i.e.* 47·5 degs. The outline of this thread is in fig. 3, A B F L P T U.

This piece B is to be used solely for cutting the thread of the nut gauge C.

C. A nut gauge, the thread of which is cut by the tap B, the crest being afterwards reamered out to such a diameter as experience may show is necessary to give suitable minimum clearance at this point to ensure

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that machine-made screws will enter the nuts or tapped holes. The outline of this is A B E G L O Q T U.

D. A notch gauge to test the core diameters of male screws.

E. A hole limit gauge to test crest diameters of male screws and to be checked by piece A. The diameter of this is diameter D, fig. 1, Schedule I.

F. A cylinder plug gauge to test the diameter of the hole in the gauge nut C in commercial nuts or tapped holes.

The diameter of this is diameter C, fig. 1, Schedule I.

2. That the standard B.A. screw be defined as a screw which conforms to the gauges described above in all respects except in the form of the crest and root of the thread, which are unimportant.

R. E. CROMPTON.
J. M. GORHAM.
G. K. B. ELPHINSTONE.
MARK BARR.
C. VERNON BOYS.
O. P. CLEMENTS.
W. A. PRICE.

APPENDIX.

The Committee have had constructed for them by the Cambridge Scientific Instrument Company a machine for measuring small screws microscopically. In figs. 4 and 5 are given drawings of the instrument, of which fig. 4 is a plan of the compound stage with the microscope removed, and fig. 5 is an end elevation showing the arrangement of the microscope. The screw to be measured is held in a spring chuck in the spindle (A). By means of the two micrometer screws, S_1 S_2, the screw is moved along geometric slides in two directions at right angles. The screw is aligned parallel to the micrometer S_1 by the adjusting screws B C. The pitch of the micrometer screws (which were supplied by the Browne and Sharpe Company) is 0·5 mm., and the heads are divided into fifty parts, enabling readings to be taken directly to 0·01 mm.

The screw is illuminated from below by a plane mirror and is observed by the microscope M. Rough focussing is effected by sliding the microscope in the tube T, the fine adjustment being accomplished by the micrometer screw S_3, which raises and lowers T. The tube T can also be rotated about its axis without disturbing the focus, and the amount of rotation measured by means of a scale on D. The eyepiece and object-glass of the microscope are by Zeiss. The eyepiece is furnished with suitable cross-wires in silver.

A series of spring chucks for different diameters of screws accompanied the machine.

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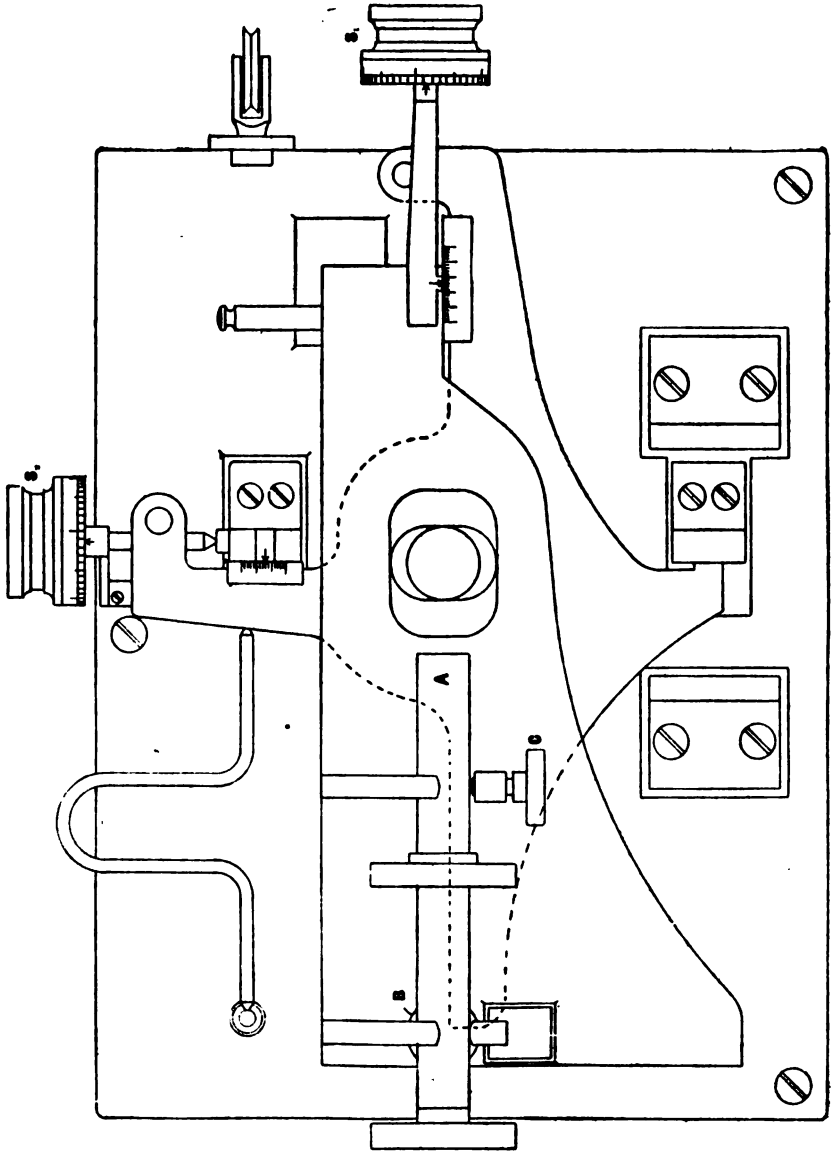

FIG. 4.

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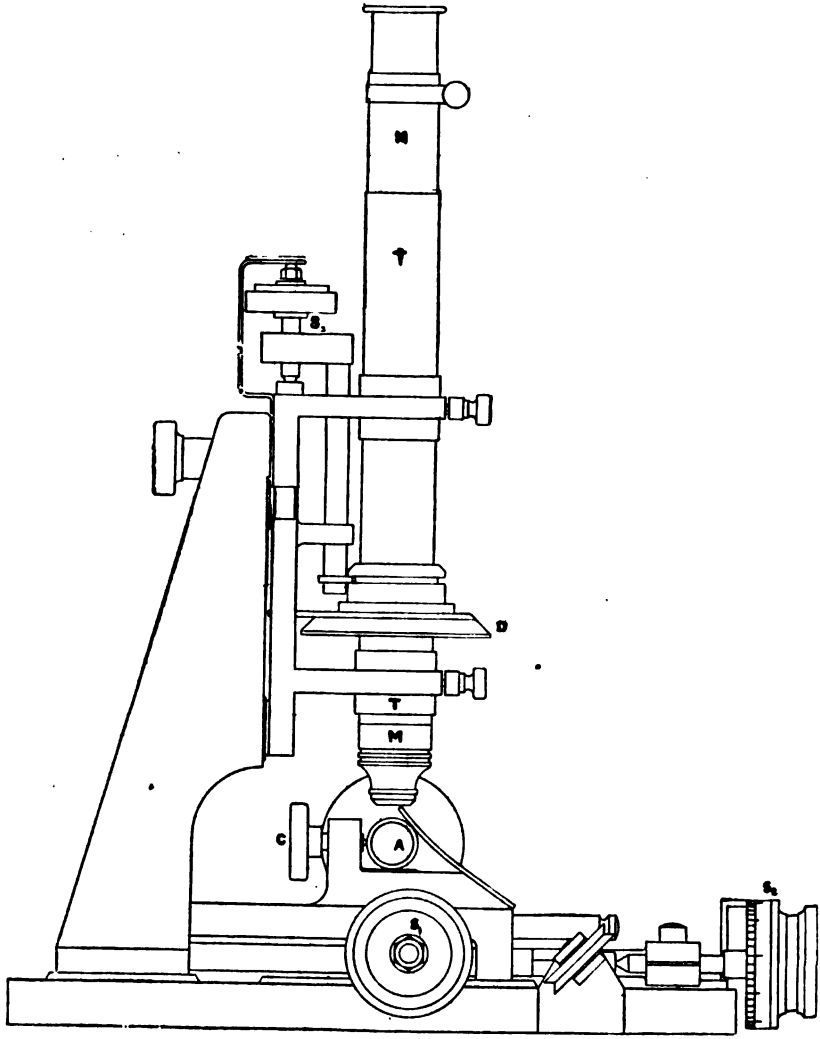
FIG. 5.



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Anthropometric Investigation in Great Britain and Ireland.—Report of a Committee consisting of Professor J. CLELAND (*Chairman*), Mr. J. GRAY (*Secretary*), Dr. T. H. BRYCE, Professor D. J. CUNNINGHAM, Professor A. F. DIXON, Mr. E. N. FALLAIZE, Dr. A. C. HADDON, Dr. D. HEPBURN, *and* Mr. J. L. MYRES.

THE following circular, which was sent to certain persons and institutions known to be engaged in anthropometric work in the British Isles, and to a few of the more distinguished physical anthropologists in foreign countries, will explain the objects for which the Committee was formed :—

British Association for the Advancement of Science.

.....1903.

DEAR SIR,

A Committee, consisting of Professor J. Cleland (*Chairman*), Mr. J. Gray (*Secretary*), Dr. T. H. Bryce, Professor J. D. Cunningham, Professor A. F. Dixon, Mr. E. N. Fallaize, Dr. A. C. Haddon, Dr. D. Hepburn, and Mr. J. L. Myres, has been appointed by this Association to organise Anthropometric Investigation in Great Britain and Ireland.

The objects which the Committee have in view may briefly be stated to be as follows :—

1. To establish uniform standards in Anthropometric Investigation.
2. To ascertain which measurements are likely to prove the most fruitful in result.
3. To formulate broad lines of co-operation.

Much valuable work done in various parts of the country in this branch of Anthropological Science is at present very imperfectly utilised, owing to the difficulty of obtaining information as to the centres at which it is carried on, and because different methods of measurement are employed at different centres. The Committee, therefore, think it desirable to obtain information regarding these methods, in order to consider which are most to be recommended for utility, accuracy, and convenience, and in the hope that a consistent scheme may be formulated for general use throughout Great Britain and Ireland.

For this purpose certain questions have been drawn up, which will be found on the annexed sheet, and I am desired by the Committee to request your co-operation in furthering its objects by answering these questions and returning your answers to me at your early convenience.

I am,
Yours faithfully,
J. GRAY.

All communications should be addressed to me :—

Anthropological Institute,
3 Hanover Square,
London, W.

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1. Are you engaged in any anthropometric investigations? If so, what measurements do you usually take, and what classes of people have you measured? (Enclose copy of Schedule in use, if any, adding description of exact mode of measurement.)

2. What instruments are you accustomed to use for making the measurements?

3. When were the measurements first taken, and over how long a period are your records of measurements available?

4. Are the measurements published? If so, in what form, in full or in abstract? If in abstract, are the original records available?

5. With what object have the observations been made—*e.g.* identification; registration of growth [1]; detection of racial differences; correlation with occupations; determination of influence of relationships; or other purpose?

6. Have assistants been employed in making any of the measurements? If so, have they received any special training, and of what kind?

7. How far do you regard the results which you have obtained hitherto as satisfactory; and what modifications, if any, are suggested by your past experience?

8. Add any remarks not falling within the previous headings.

Forty-seven circulars were sent out and sixteen replies were received. A summary of the replies is given in the Appendix.

The following remarks and suggestions originating out of the Secretary's report have been drawn up by the Chairman of the Committee:—

Remarks and Suggestions by Professor CLELAND.

It is disappointing that so few answers have been given in response to the Committee's circular, and that those which have been sent show in so many cases work confined to certain departments of Anthropometry to the exclusion of others; but, having been kindly furnished by our Secretary and Reporter, Mr. Gray, with a sight of the materials at his disposal, I cannot refrain from expressing my belief that he has made out of them as much as could be made.

So far as explicit answers to the questions in our circular are concerned, the Committee cannot be said to have been very successful, but the absence of direct results in that respect suggests the question how far this or some such Committee may be of use by itself proposing some such method of research as may with advantage be generally adopted with a view to the facilitation and organisation of research.

The following suggestions occur to me:—

1. Inasmuch as age and sex are of themselves sources of variations of most distinct descriptions, I should say that, except for the purpose of studying these two kinds of variations, measurements should all be made on males not younger than 30 years and not older than about 45. I have shown in the 'Philosophic Transactions' many years ago that the male growth is typical, and that the deviations which occur in the female are inconstant in nature and degree. I base my recommendation, both in respect of age and of sex, on my own experience in craniometry, but I would extend it to measurements of all parts of the body.

[1] In this case state at what intervals the measurements were repeated.

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II. Absolute measurements are more valuable than any percentage proportions or so-called indices. Indices can be easily calculated when the absolute measurements are given on which to base them. The so-called cranial index, or proportion of breadth of skull to length, I have 34 years ago proved to be utterly valueless. The proportion of height of skull to length leads to much more natural grouping of nationalities. It is well known that the tendency to length of skull increases with stature, and therefore when it is possible the total stature should be given along with the cranial measurements.

III. In racial investigations on the living, and in class investigations, as of soldiers, trades, and schoolboys, as also in estimation of peculiarities characteristic of different parts of the country, I should recommend such a plan as the following :—

A. MEASUREMENTS OF HEAD.—1. Length from glabella to occipital probole. 2. Radial length-measurements of cranium (as suggested by Busk) from orifice of ear to nasion, glabella, middle frontal distance, fronto-nasal and fronto-parietal points, and the vertex or greatest height between these two last—occipital probole and occipital tuberosity. 3. Facial length measurements from orifice of ear to base of columella of nose, tips of upper incisors, and prominence of chin, as also the distance from nasion to base of columella.

B. MEASUREMENTS OF BODY AND LIMBS.—1. *Stature* should be measured : (*a*) standing, with the shoes off, and during a full inspiration ; (*b*) sitting well back and upright against a wall, and in full inspiration.

2. *Breadth of shoulders* from outside the head of the humerus, with the arms by the side.

3. *Intertrochanteric breadth.*—The breadth at the crest of the ilium may for ordinary purposes be neglected, seeing that, as I have shown, it is increased by muscularity and by want of resistance in the special textures.

4. *Span*, with the arms stretched horizontally, the palms looking forwards. This is the most reliable mode of measuring length of arm.

5. *Hand*, length, and the breadth of palm across the knuckles.

6. *Foot*, length, and breadth at balls of toes. Both measurements should be taken with the weight of the body pressing the foot flat against the ground.

7. *Chest circumference*, in full inspiration, measured by a tape at the level of the lower end of the mesosternum. This measurement deserves special attention, as the notion on which importance is given to it in selection of recruits is manifestly unsound, inasmuch as a large chest with a small vital capacity means inactivity of the individual parts of the lungs, and liability thereby to phthisis ; and therefore a large chest is of questionable advantage, except when accompanied with proportional activity of respiration.

IV. Weight should always be attended to in measurements, testing health during growth. It should be taken in schools at regular intervals and frequently.

So much for the question of selection of measurements ; but if the Committee is to be of use it must get its methods employed, and must gather together the work received so as to obtain results.

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For these purposes the Committee would have to be continued, and must enter on a new labour. I should recommend that (as I have already indicated) it should confine itself to measurements of the living, leaving the study of human remains, as a large and very different subject, to be taken up by individual anatomists skilled in its intricacies.

A deputation might be empowered to communicate with the War Office to instruct medical officers at the military depôts to help by filling up, in the case of as many soldiers as they may be disposed to measure, the details of a schedule to be furnished by the Committee, the schedule mentioning, in addition to measurements, the name, birthplace, and age of the soldier examined. By this means the variations of adult males in different districts may easily be ascertained systematically.

In like manner the Education Department might be communicated with to get the head masters of Board schools to fill up schedules of measurements, weight, age, and birthplace of each of the boys and girls under their charge. The schedules sent to schools should be kept as simple as possible, especially in view of the measurements and weights requiring to be repeated at stated and not too distant periods.

Probably the results to be obtained by collation of schedules will be best worked out by Government employees, and this opens up the question whether it may not be best for the Committee of the Anthropological Section to prepare suitable schedules and get the Council of the Association to approve them, and approach Government through a deputation headed by the President of the Association.

The following Report has been drawn up by the Secretary, and embodies suggestions made by certain other members of the Committee:—

The replies to the circulars show that the number of measurements made on each subject by different observers varies from the four to six measurements made on boys at public schools to some 160 measurements or observations made in the Anthropometric Laboratory at Florence.

Among the instruments stated to be in use are Matthieu's, Garson's, Cunningham's, Gray's, Gladstone's, and Matthew Hay's.

If we except veterans like Dr. Beddoe, most of those who have replied to the circular have commenced Anthropometric work within the last few years. At the present time there is a promising increase of activity both among private investigators and in connection with High Schools.

In the Appendix there will be found references to publications describing methods or results of Anthropometric work.

The objects of the observations mentioned include most of those enumerated in question 5. At schools the objects are usually the registration of growth, though in some cases, as at the Grammar School, Aberdeen, much more extensive observations are made, as may be seen by the schedule published in the Appendix. Dr. Gladstone's investigations have in view the determination of the correlation between the size of the head and intellectual ability.

Most of the correspondents insist on the importance of the training of assistants.

With a few exceptions, the results of the measurements are considered satisfactory. Mr. Meyrick considers that chest measurements and circumference measurements of the head are untrustworthy; Dr. Gladstone is also of the same opinion. Professor Reid recommends greater simplicity of the schedule. Mr. Galton recommends the applica-

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tion of the Higher Statistical Methods developed by Professor Karl Pearson.

The Committee considers that the objects which it has in view, as stated in the circular above, would be best attained by establishing a Central Bureau or Laboratory, which would collect and disseminate information on anthropometric work, give practical instruction in measurements, and supply schedules.

By this means uniform standards in anthropometric investigations would be secured, measurements best suited for any specified investigation could be recommended, and co-operation between investigators could be secured. The Laboratory could also measure and give certificates of measurements when desired. Since the abolition of Mr. Galton's Anthropometric Laboratory at South Kensington no convenient place has been available in London where any member of the public could go to be measured, and judging from letters which have appeared in the newspapers (see 'Times,' July 21, 1902), there appears to be a demand for such an institution. The Laboratory which the Committee recommend would supply this demand, and the statistics collected would, in the course of time, form very valuable material for determining the physical characteristics of the British people. This Laboratory need not be made a new centre of activity, but should preferably be offered to some existing institution such as the Anthropological Institute.

The Committee beg to acknowledge the assistance given by the Anthropological Institute in providing headquarters for the Committee.

The Committee desire to be reappointed with instructions to carry out the recommendations in the Chairman's report, and to draft a scheme for such an Anthropometric Laboratory as is suggested above.

APPENDIX.

British Isles.

BEDDOE, J., F.R.S., uses callipers, the compas glissière, and tape. He has taken measurements, of all kinds of people, during many years. Most of these measurements have been published by the old Anthropometric Committee of the British Association, the material being still in Dr. Beddoe's possession, also in Dr. Beddoe's works 'Stature and Bulk' and 'Races of Britain,' and in several papers. For head measurements Dr. Beddoe considers that no assistant should be employed who has not been personally trained and watched.

BROWNE, C. R., M.D. (Trinity College, Dublin), writes that in the Anthropological Laboratory, Trinity College, Dublin, conducted by himself, under the supervision of Professor D. J. Cunningham, measurements have been made since 1891 of students of Trinity College, Dublin, and of peasants of the farming and fishing class in the West of Ireland. The instruments used are (for field work) Garson's anthropometer, Henry's self-registering craniometer, compas glissière, and Flower's craniometer; (for laboratory work) Flower's craniometer, Garson's instruments, Cunningham's radial craniometer, and Watson's index calculator. The measurements are nearly all published in the 'Proceedings of the Royal

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Irish Academy.'[1] The principal objects of the observations are registration of growth (at six-month intervals), correlation with occupations in laboratory work, and detection of racial differences, &c., in field work. Assistants trained by Dr. Browne were employed in making measurements. Dr. Browne agrees with Mr. Meyrick and Dr. Gladstone that chest measurements and circumferences of the head are unreliable; he considers that the schedule used should be as simple as possible. Assistants should have a thorough practical training in measuring; unskilled measurers are liable to make grave mistakes. Schedules used in the laboratory and for field work have been received from Dr. Browne. He considers it very desirable that a common form of schedule, or at least a common series of observations, should be drawn up for the use of all observers. He also recommends that standard skulls should be used for checking and verifying methods of measurement.

CUNNINGHAM, D. J., M.D., F.R.S. (Professor of Anatomy, The University, Edinburgh), writes that anthropometrical work has been carried on for the last ten years in the Anthropological Laboratory of Trinity College, Dublin. The Irish Laboratory has published numerous Reports in the 'Proceedings' of the Royal Irish Academy, giving the results not only of its Dublin work, but also of its yearly peripatetic field work (see Browne, C. R., M.D.).

DUCKWORTH, W. L. H. (University Lecturer on Physical Anthropology, Cambridge), writes that the Anthropometric Committee of the Cambridge Philosophical Society maintains an assistant who measures all University members who present themselves at the Library of the Society. The principal measurements are stature, span, length, breadth, and height of head; physiological measurements, *e.g.*, visual acuity, strength of grasp, lung capacity, are also made. In the University Laboratory of Anthropology, instruction in Anthropometry is given, but no local research is being conducted at the present date (August 1903).

[1] The following is a list of papers on work done in connection with the Anthropometric Laboratory, Trinity College, Dublin: Part I. Laboratory Work.—1. 'Some New Anthropometrical Instruments, C. R. Browne, M.D. (*Proc. Roy. Irish Acad.*, 3rd Series, vol. ii. No. 3). 2. 'On some Crania from Tipperary,' C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. ii. No. 4). 3. 'Studies in Irish Craniology: the Aran Islands, Co. Galway,' Professor A. C. Haddon (*ibid.*, 3rd Series, vol. ii. No. 5). 4. 'On some Human Remains recently discovered near Lismore,' D. J. Cunningham, M.D., F.R.S., and C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. iv. No. 4). 5. 'Report on some Osseous Remains found at Old Connaught, Bray, Co. Dublin,' D. J. Cunningham, M.D., F.R.S., and C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. iii. No. 5). 6. 'Report on Prehistoric Burial near Newcastle, Co. Wicklow,' George Coffey, C. R. Browne, M.D., and T. J. Westropp, M.A. (*ibid.*, 3rd Series, vol. iv. No. 4). 7. 'Report on the Work done in the Anthropometric Laboratory of Trinity College, Dublin, from 1891 to 1898,' C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. v. No. 2). Part II. Field Work.—1. 'The Ethnography of the Aran Islands, Co. Galway,' Professor A. C. Haddon and C. R. Browne, M.D. (*ibid.*, 1893). 2. 'The Ethnography of Inishbofin and Inishshark, Co. Galway,' C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. iii. No. 2). 3. 'The Ethnography of the Mullet, Inishkea Islands, and Portacloy, Co. Mayo,' C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. iv. No. 1). 5. 'The Ethnography of Clare Island and Inishturk, Co. Mayo' (*ibid.*, 3rd Series, vol. v. No. 1). 6. 'Ethnography of Garumna and Lettermullan, Co. Galway,' C. R. Browne, M.D. (*ibid.*). 7. 'The Ethnography of Carna and Mweenish, Co. Galway,' C. R. Browne, M.D. (*ibid.*, 3rd Series, vol. vi. No. 3).

Papers will shortly be published on the following districts: Dunquin, co. Kerry; Malinmore and Malinbeg, co. Donegal; the district of Ardmalin, co. Donegal (by C. R. Browne, M.D.).

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The chief instruments used are Flower's craniometer, Martin's traveller's anthropometer, Pearson's headspanner.

The records of the Anthropometric Committee of the Philosophical Society extend over many years, and they were used about 15 or 20 years ago by Dr. Venn in a paper entitled 'Cambridge Anthropometry' ('Jour.' Anth. Inst.) (see also Horton-Smith in 'Nature' about 1895). Measurements for crania and on living persons are published in the 'Journal' of the Anthropological Institute and in the 'Journal' of the Camb. Phil. Society. (See a pamphlet on the 'Anatomical Museum at Cambridge,' by W. L. H. Duckworth.)

The observations used by Dr. Venn enabled him to compare, in respect of physical development, men who in their final examinations took 1st, 2nd, and 3rd classes respectively. Otherwise, detection of racial differences has been the chief object of research.

The Camb. Phil. Soc. maintains an assistant who has been instructed how to make the observations: this assistant does not appear to have attended any special course of instruction on the principles of anthropometry.

The measurements made in connection with the Philosophical Society have been but little utilised. At the University Laboratory, instruction has been given to about 300 students in the last four years, and about two per cent. of these have up to the present contributed to our knowledge of general anthropology. As the great bulk of these students are still pursuing their medical studies, it is still early to pronounce on the final results of the instruction given, for naturally medical students have but little time for the pursuit of such researches as are the subject of inquiry here.

Galton, Francis, F.R.S., refers to the list of papers published by him in the Royal Society Catalogue of Scientific Papers. He says: 'The conclusions to which a great many and various experimental inquiries have led one are a distrust of statistical results unless the data are collected under conditions that (1) *wholly exclude bias* and (2) the occasional presence of *large disturbing influences*. I do not think that laxity in measurement matters much, so long as laxity does not lead to error in *one* direction; in fact, I know that a vast deal of effort is wasted in minuteness of measurement. In speaking of bias, I mean, not only personal (often unconscious) bias, but any influence that gives a one-sided direction to the results. An instrument that has a sensible index error, which is not allowed for, gives a bias to the results. In every new proposed inquiry, great pains and much consideration should be given before beginning it, to be sure that the plan is not vitiated by unsuspected causes of error.'

Mr. Galton considers that 400 cases, of which the two sets of 200 agree, are quite sufficient for any statistical investigation. The probable error of the result should always be calculated and given. He highly recommends the methods of the higher statistics as so greatly advanced by Professor Karl Pearson.

Garson, J. G., M.D., has described his method of measurement and instruments in 'Notes and Queries on Anthropology,' published by the Anthropological Institute. He uses callipers, steel tape, set squares, and sliding rules of various kinds. He has designed a combination instrument called the 'Traveller's Anthropometer' by which all the usual measurements can be made.

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The classes he has measured during the past 16 or 17 years are the professional classes and criminals. His results are published in the British Association Reports and in the 'Journal' of the Anthropological Institute. The objects of his observations were chiefly to determine racial differences and range of variation, and for identification. Assistants thoroughly trained by himself have been employed. He considers that the measurements taken should depend on the nature of the investigation.

GLADSTONE, R. J., M.D. (Middlesex Hospital), writes: 'I am at present engaged in an anthropometric investigation, and the principal measurements which I have taken are the *stature* and *body weight*, along with the following head measurements:

(*l*) *Length*—from glabella to occipital point.
(*b*) *Breadth*—greatest transverse diameter above zygomatic arches.
(*h*) *Height*—from biauricular line to vertex.
(*c*) *Circumference*—taken in a horizontal plane, passing through a point just above the glabella in front, and the occipital point behind.
'In *post-mortem* subjects I have also recorded the *weight of the brain*.'

'My measurements have included the following groups:—

'The Students of the Middlesex Hospital.
'The Medical Staff of the Middlesex Hospital.
'The Porters and Male Servants of the Middlesex Hospital.
'Boys of St. Katherine's School, Regent's Park.
'100 Female Inmates of St. Pancras Workhouse.
'50 Male Inmates of St. Pancras Workhouse.
'Male and Female Subjects in the *post-mortem* room of the Middlesex Hospital.

'I inclose the schedule which I have used to record data, for the first three groups; I have however, in addition to the items indicated in it, taken full and profile photographs of the head and shoulders, and the horizontal contour of the head.

'2. I have used your (Gray's) callipers for taking the longitudinal and transverse diameters of the head; and the instrument you had made for me for taking the height from the biauricular line to the vertex. In using this I take special care that both the head and the instrument are held vertical.

'3. My first measurements were taken in May 1901, and I have continued taking measurements up to the present time (1 year 10 months).

'4. In November of last year (1902), I gave a preliminary communication embodying some of my results to the "Anatomical Society of Great Britain and Ireland," and showed a series of tables giving the average measurements of different groups; the Society are publishing the communication with the tables in the "Journal of Anatomy and Physiology." This communication does not include the records from the *post-mortem* room, which are not yet complete, and in making use of these I hope to have the assistance of Professor Karl Pearson.

'5. One of my chief objects in this investigation has been to determine whether there is, or is not, any variation in the size and shape of the head correlated with varying degrees of mental ability; and if so in what direction, and to what extent. In carrying out this part of the inquiry I have classed the individuals composing the first two groups, and

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the boys of St. Katherine's School, into three divisions, according to whether they possess a high, average, or low degree of mental ability, and have compared these classes with one another.

'From the *post-mortem* records I hope to obtain a formula, by which the approximate brain weight may be calculated from outside measurements, and to ascertain the extent to which variation may occur from the general mean, among cases which may be considered as normal.

'6. The majority of my measurements have been taken by one assistant—a gentleman in whose accuracy and care I have every confidence; the *post-mortem* cases have been measured by a second assistant, who is equally conscientious and trustworthy.

'I have myself explained to them the method of using the instruments, and the importance of accuracy in making and recording each measurement.

'7. As far as they go, my figures appear to indicate a correlation between large size of head and a high degree of mental ability, but there are many exceptions to the rule. These I believe to be accounted for chiefly by race differences.

'The results which I have obtained in the different groups appear to accord very closely with one another, and with the results which have been published by Alfred Binet in "L'Année Psychologique," 1901; my figures are, however, much smaller than those of Professor Binet, and others which have been published in this country, and I shall therefore most gladly co-operate with the Committee of the British Association by allowing my figures to be used in combination with others, if desired.

'With regard to modifications of my previous work, I should be inclined to discard the longitudinal and transverse arcs of the head, in preference for the "minimal frontal diameter" of Broca. The external occipital protuberance is in many subjects quite indefinite, and all tape measurements vary considerably with the condition of the hair; so that although I have taken these two tape measurements and the horizontal circumference, I have not made use of them in estimating capacity.

'I believe a few principal measurements such as the longitudinal, transverse, and vertical diameters taken accurately will furnish far better results than a large number of subsidiary measurements which enormously complicate statistical work, and, at least for the purpose which I have had in hand, are of very questionable value.

'In investigating the influence of any particular characteristic, such as mathematical or musical talent, a great deal of valuable time may be saved by simply comparing the extremes with one another, and if the average measurements have been found for the particular country or district, I should regard it as unnecessary to measure the average individuals in whom the characteristic in question was neither conspicuously developed or altogether absent.

'I think much may be gained by careful selection, and grouping of the individuals measured, and that, on the other hand, there is a danger in dealing with a large number of figures obtained from different sources of losing in the general mass, class, or type characteristics which may be of great significance.'

Gray, J., B.Sc., and Tocher, J. F., F.I.C., have been engaged on anthropometric work since 1895. The measurements usually taken were length and breadth of head, and height standing and sitting. The class of people measured were farm labourers and artisans in rural districts in

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East and West Aberdeenshire. About 400 persons have been measured in East Aberdeenshire, and about 100 in West Aberdeenshire. A pigmentation survey of about 15,000 school children in East Aberdeenshire has also been carried out.

The instruments used were a compass callipers, and Gray's sliding callipers; a specially designed stand and chair for measuring height standing and sitting was used.

The measurements are published in the 'Journ.' Anthrop. Inst., 1900, and in the 'Trans.' of the Buchan Field Club.

Some of the measurements have been made by trained assistants, but the most of the measurements have been made by themselves.

The objects of these measurements have been the detection of racial differences.

The results show that the population of Aberdeenshire is very much darker than that of Scandinavia and North Germany. There is, however, a certain percentage of the blond Scandinavian element, which decreases as we go inland. The predominant brunette element is very broad-headed and tall, and appears to correspond to the early British bronze-age type.

Experience suggests the necessity for thorough practical training for assistants, who should be drilled under an expert instructor till they can without fail make accurate measurements.

Messrs. Gray and Tocher are also engaged in measuring the inmates of lunatic asylums in Scotland with the view of ascertaining whether there is any correlation between external physique and insanity.

Mr. Tocher, through an assistant, measured a number of Esquimaux. The analysis of the results is published in 'Man,' 1902.

Mr. Gray measured about 100 natives of India in the Coronation contingent, and about the same number of natives of Africa, Fijians, Maoris in the Colonial Coronation contingent. The results of the Indian measurements are published in 'Man,' May 1903. The African &c. measurements will be published at an early date in the 'Journ.' Anthrop. Inst.

Hay, Matthew, M.D. (The University, Aberdeen), has recently examined and measured 600 school children between the ages of six and fifteen for the Royal Commission on Physical Training. His schedule is very elaborate, and provides for a record of measurements, pigmentation, tests of sight and hearing, intelligence, and other characteristics. The instruments used were several instruments devised by himself for measuring height, standing and sitting, height of head, &c., and Gray's callipers. All the measurements were made in November 1902. The results will be published in the report of the Royal Commission, and the original records are available. Medical graduates were employed as assistants. The results obtained are considered to be very satisfactory.

Myers, C. S., M.A., M.D., has measured (1901–1902) about 1,300 Soudanese and fellaheen. He measured stature with tape and set square; for the face he used the ordinary compass callipers, and for other measurements of the head, Gray's callipers. His schedule specified 46 measurements. A special feature of his measurements is a number of radii measured from the biauricular line. For this purpose he used the instrument used by Dr. Gladstone, with an attachment for measuring angles devised by himself. The objects of his observations were the detection of racial differences and the determination of the

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comparative physical efficiency of the Egyptian army. The measurements have not yet been published.

He, as a result of his experience, recommends that anthropometric workers should be specially trained, and should be supplied with models and figures whose dimensions have been standardised by approved investigators. Frequent recourse should be had to these models to prevent unconscious deviation from recognised methods of measurements.

MEYRICK, E. (Marlborough College), writes that measurements have been taken at Marlborough College since 1874, chiefly with the object of registering growth. The measurements taken are height, weight, chest expanded, chest emptied. The measurements are taken by college masters of scientific and mathematical training. He considers that chest measurements, and other measurements dependent on the intelligence or will of the subject, are unreliable, and circumference measurements of the head vary with the quantity of the hair. The only measurements he finds reliable are height and weight.

MARSHALL, J., M.A., LL.D. (Rector, Royal High School, Edinburgh), writes that measurements have been taken since 1899 for the registration of growth, the results being communicated to the parents. The measurements taken are height, weight, chest, forearm, upper arm, and they are made by the senior gymnastic instructor. These measurements have been found valuable as a guide at times when boys show languor in work.

REID, R. W., M.D. (Professor of Anatomy, University of Aberdeen), has measured students, policemen, and asylum attendants (male and female). The instruments used are Flower's and Gray's callipers for head measurements, and the usual instruments for height and span. Measurements were first taken in 1896, and measurements for seven years are available; they have been partly published in abstract. The objects of the investigation are registration of growth and correlation with occupations. Trained assistants have been employed. He regards his results so far as satisfactory, and considers that any modification ought to aim at greater simplicity of schedule. Copies of schedules have been sent. Over thirty measurements are made on each subject.

SIMPSON, H. F. M., M.A. (Rector, Aberdeen Grammar School), commenced measurements in March 1903. A copy of the very complete schedule used has been sent. The main object of these measurements is educational, and to indicate the probable effect of physical deficiencies on the boy's progress. The results so far appear to show that good physique is associated with high intelligence. Besides the usual measurements, tests of sight and hearing are made. The boy's position in games and other physical exercise is also noted.

TURNER, SIR WILLIAM, refers to his memoir on Scottish crania in 'Trans.' Roy. Soc. Edinburgh, vol. xl., part iii., 1903, for an account of the anthropometrical methods followed by him.

From the above memoir it appears that over sixty points are noted on each skull, half of which relate to the size of the cranial cavity and half to the facial part of the skull. Included in the first set of measurements are cubical capacity of the skull, five diameters of width, one of length, and one of height. The circumference of the skull is taken in four directions, and eight radii are measured. From these measurements nine indices are calculated.

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Foreign.

HRDLICKA, A. (Museum of Natural History, New York), measures whites and negroes, but especially Indians. His schedules are made up in book form to contain measurements and observations on 100 individuals. In each book there are three kinds of schedules, entitled (1) Measures, (2) Inspection, (3) Physiological and medical. The instruments used are Matthieu's (Paris) compas à épaisseur, compas glissière (all frequently controlled by standard), large aluminium chest compass, tape (such as used in l'École d'Anthropologie), dynamometer, thermometer. Measurements have been taken since 1897. Anthropological observations on about 1,000 white and 100 coloured children have been published. Original records of about 2,000 Irish, English, Americans, &c., may be available.

The objects of the investigations have been: Registration of growth, detection of racial differences, correlation with occupations, but especially the study of variation. In only one instance have assistants been employed, and these have been personally trained and supervised. Work done on other races than whites is considered to have been the most satisfactory. Among whites, mixture, occupation, health, but especially pathological condition, introduce many new factors.

Dr. Hrdlicka considers that the most prominent subjects for investigation are: (1) Racial studies; (2) The study of normal children (white) in every aspect; (3) A thorough study in any direction of individuals (living and dead), the most specialised (functionally); (4) Studies on families and homogeneous communities.

From these studies he considers that we may expect not only to accumulate a positive knowledge, but also to determine the circumstances most favourable or most detrimental to development. It is also probable that some tendencies of development among the whites can be established. The essential thing in all these investigations, however, is the quality, training, and experience of the workers.

MANOUVRIER, Dr. L. (Laboratoire d'Anthropologie à l'École pratique de la Faculté de Médecin), writes that the committee will be able to find complete information as to the methods employed in his laboratory (which is that of Broca) in the memoirs published by himself and his pupils. The following is a list of the most important of these memoirs:—

1. 'Dr. Godin: Recherches anthropométriques sur la Croissance des diverses parties du corps.' (Paris. Maloine, éditeur.)
2. 'Dr. Papillault: L'homme moyen à Paris.' (Bulletin Société d'Anthrop. 1902.)
3. 'Dr. L. Manouvrier: Étude sur les rapports anthropométriques en général et sur les principales proportions du corps.' (Mémoires de la Soc. d'Anthrop. 1902.)

He published some years ago two memoirs which may be of special interest to the Committee, copies of which he has sent to the Anthropological Institute.

1. 'Généralités sur l'Anthropométrie.' (Revue de l'École d'Anthrop.)
2. 'Aperçu de céphalométrie anthropologique.' (Extrait de l'Année psychologique, 1896.)

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In these works will be found the system of anthropometry carried out in his laboratory, where more than 100 measurements are made on each subject. In order to carry out this system successfully a very rigorous technical training is necessary. An experience of more than twenty years has convinced Dr. Manouvrier of the necessity for a practical and very careful training in the technique of anthropometry, even when a small number of simple measurements have been selected.

Uniformity and accuracy are very difficult to obtain when an investigation is carried out by several persons. Repeated comparison and mutual checking are necessary if an investigation is continued for a long time.

Mochi, Dr. A. (Assistant Professor of Anthropology, Florence), has sent the following letter and three memoirs :—

'Società Italiana d' Antropologia, Via Gino Capponi 3, Florence.
'*November* 21, 1903.

'Dear Sir,—This Society received one of your circulars relative to an inquiry into the Anthropometrical methods adopted in England and Ireland—an inquiry intended to establish a basis of co-operative action in accordance with the methods and principles which obtain amongst the various students of Anthropometry in your country.

'In the above circular I was entrusted with the task of reporting thereon, a task which I discharged at the meeting held on March 15, 1903, whilst I explained its import and paid homage to your initiative. When the account of said meeting has been published in the "Archivio per l' Antropologia," you will be able to see what I said on that occasion in regard to your work.

'In the meantime I take the liberty of sending you some of our literature relative to Anthropometry, and I shall invite Dr. R. Livi, Dr. N. Pizzoli, and other Italians to also send you their publications relative to the question. In establishing the basis for a plan of Anthropometrical research to be adopted in England and Ireland, you will have before you what has been done by us in that science. I take this opportunity to tender you and the Committee my personal homage.

'(Signed) Dr. A. Mochi,
'Assistant Professor of Anthropology.'

The literature received from Dr. Mochi is :—

1. 'L' instituzione di un laboratorio antropometrico nel Museo Nazionale d' Antropologia dell' Instituto di Studi Superiori in Firenze.' Dr. A. Mochi.
2. 'L' Antropometria nelle scuole.' Dr. A. Mochi.
3. 'L' Antropologia nell' insegnamento universitario e l' antropometria nella scuola di Paolo Mantegazza.'

In the first of these memoirs a list of measurements and observations to be made on each subject is given. This list comprises more than 160 categories ; and the characters to be noted are divided broadly into (1) Morphological, and (2) Physiological.

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Archæological and Ethnological Researches in Crete.—Report of the Committee, consisting of Sir JOHN EVANS (*Chairman*), Mr. J. L. MYRES (*Secretary*), Mr. A. J. EVANS, Mr. D. G. HOGARTH, Professor A. MACALISTER, *and* Professor W. RIDGEWAY.

THE grant which was assigned to the Committee was applied in equal parts in aid of two distinct researches :—

(1) To enable Mr. Arthur Evans to continue his excavation of the Palace of Knossos and its surroundings a sum of 50*l.* was paid over to the treasurer of the Cretan Exploration Fund and duly expended in the campaign of 1903. Mr. Evans's report is appended.

(2) The other sum of 50*l.* was placed at the disposal of Mr. W. L. H. Duckworth, M.A., Fellow of Jesus College, Cambridge, and University Lecturer in Anthropology, who undertook in consideration of this grant and of a grant from the British School of Archæology in Athens to make a study of the human remains which were being discovered in prehistoric burial-places in the British School's excavations at Palæokastro, in Eastern Crete ; and also to make a preliminary study of the anthropography of modern Crete and other parts of the Ægean area. Mr. Duckworth's report of his investigation is appended.

The Committee ask to be reappointed, with a further grant.

(1) Mr. ARTHUR EVANS's *Excavations at Knossos*.[1]

It had seemed to the excavator possible that this year's campaign in the prehistoric palace at Knossos might have definitely completed the work. But the excavations took a wholly unlooked-for development, productive of results of first-rate importance both on the architectural and general archæological side, and calling still for supplementary researches of considerable and indeed, at present, incalculable extent.

The search for the tombs, which was principally carried out in the region north of the Palace, only resulted in the discovery of a necropolis of secondary interest in a much destroyed condition. At the same time remains of houses were brought to light, going back to the earliest Minôan period and proving the continuous extension of the prehistoric city for a distance of over a quarter of a mile north-east of the Palace.

At its north-western angle the Palace area itself has gained a monumental accession. The building proved to extend beyond the paved court which lies on this side, and excavation here brought to light what can only be regarded as the royal theatre. This consists of two tiers of limestone steps, eighteen in number and 30 feet in width on the east side, varying from six to three, with an extension of 50 feet on the south, while between the two is a raised square platform. The steps or low seats and platform overlook a square area where the shows must have taken place. Owing to the made character of the ground to the north-east the limestone slabs on that side had either disappeared or were brought out in a much disintegrated condition, and it was found necessary for the conservation of the rest of the monument to undertake considerable restoration. This was, however, facilitated by the fact that

[1] Cf. *Proc. Brit. Assoc.*, 1902 (Belfast), p. 466, and previous reports.

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the lower courses of the outer supporting wall were throughout preserved. The theatre would have accommodated about five hundred spectators. A somewhat analogous feature was discovered by the Italian mission; bordering the west court of the palace at Phæstos; but the arrangement at Knossos is much more complete and gives us the first real idea of the theatre in prehistoric Greece. The pugilistic shows represented on certain small reliefs at Knossos and Hagia Triadha and the traditions of the 'dancing-ground' of Ariadne, executed by Dædalos for Minos, may throw a light on the character of the performances in this theatral area.

Between this building and the west court of the Palace an area was explored containing a very complex mass of constructions representing, at different levels, every age of Minôan culture, and apparently belonging to a sanctuary connected with the Cretan cult of the Double Axe and its associated divinities. Painted pottery and other objects were here found, with designs referring to this cult. Among other discoveries were highly decorative polychrome vases belonging to the 'Middle Minôan' period, more or less contemporary with the twelfth dynasty of Egypt. Of later palace date was an extremely important deposit consisting of a bronze ewer and basins, with exquisitely chased ornamentation in the shape of lilies and various kinds of foliage.

On the north-east of the Palace, built into the side of the hill, was uncovered a remarkably well-built house, constructed largely of fine gypsum blocks, which appears to have been a kind of royal Villa. Here, as in the domestic quarter of the Palace, the upper story is also well preserved, and there are two stone staircases, one with a double head. On a landing here was found a magnificent painted jar containing reliefs of papyrus plants in a new technique. The principal chamber was a columnar hall with a *tribuna* at one end, backed by a square apse containing the remains of a gypsum throne, the whole presenting an extraordinary anticipation of the later basilica.

Within the previously uncovered Palace area supplementary explorations of lower levels have been carried out on an extensive scale. A whole series of deep walled chambers, perhaps representing the dungeons of an earlier palace, have been opened out. Excavations below the floor-level of the Olive Press area have brought to light the floor-levels of more ancient chambers containing exquisite painted pottery belonging to the middle Minôan period and sealings throwing an interesting new light on its glyptic art and the early 'pictographic' type of script. Beneath the pavement of the Long Gallery of the magazines a continuous line of deep stone cists (*kaselles*) was discovered, and from the remains of wooden chests inlaid with glazed ware and crystal mosaic, accompanied by quantities of gold foil, it is clear that these repositories had once contained treasure. Near the east Pillar Room a small pit was found beneath the floor-level containing vases and other objects belonging to the earliest Minôan period that immediately succeeds to neolithic, and affording the first collective view of a representative type series of that period. The character of the glazed beads found in this deposit seems to indicate relations with early dynastic Egypt. The exploration of the neolithic stratum, which to a depth of 25 feet underlies those of the 'Minôan' buildings, was continued, several new shafts being dug within the Palace area. The successive phases of the local neolithic culture are thus becoming more clearly defined.

The investigation of the cause of a slight depression in the pavement

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of a storeroom immediately north-east of the east Pillar Room led to a discovery of extraordinary interest. Beneath the pavement and a small superficial cist belonging to the latest palace period were found two spacious repositories of massive stonework containing, in addition to a store of early vases, a quantity of relics from a shrine. These had evidently been ransacked in search for precious metals at the time of the reconstruction above, but a whole series of objects in a kind of faïence like the so-called Egyptian 'porcelain,' but of native fabric, had been left in the repository. The principal of these is a figure of a snake Goddess, about 14 inches high, wearing a high tiara up which a serpent coils, and holding out two others. Her girdle is formed by the twining snakes, and every feature of her flounced embroidered dress and bodice is reproduced in colour and relief. A finely modelled figure of a votary of the same glazed material holds out a snake, and parts of another are also preserved. The decorative fittings of the shrine include vases with floral designs, flowers and foliage in the round, naturalistic imitations of nautiluses and cockles, rock-work and other objects, all made of the same faïence. Two extraordinarily life-like groups represent a cow and calf and a Cretan wild goat and kids. The central aniconic object of the cult, supplied in the formerly discovered shrine of the Double Axe, was here a marble cross of the orthodox Greek shape. The cross also occurs as the type of a series of seal-impressions, doubtless originally belonging to documents connected with the sanctuary, found with the other relics. A number of other seal impressions deposited with these show figures of divinities and a variety of designs, some of them of great artistic value. An inscribed tablet and clay sealings with graffiti characters was also found, exhibiting a form of linear script of a different class from that of the archives found in the chambers belonging to the latest period of the Palace.

In view of these important results it is obvious that further investigations beneath the later floor-levels must be carried on throughout the palace area. The search for the royal tombs has also to be continued. The region about the theatre and the north-west sanctuary still requires methodical excavation on a considerable scale, and the neolithic strata call for continued investigation. The need for further assistance from those interested in the results already obtained is still urgent.

(2) *Report on Anthropological Work in Athens and in Crete by* W. L. H. Duckworth, *M.A., Fellow of Jesus College, Cambridge; University Lecturer in Physical Anthropology.*

Part I.—*General Report.*

In the autumn of 1902 the Director of the British School at Athens informed me that a grant of 50*l.* had been made by the Cretan Committee of the British Association in aid of physical anthropological investigations in Crete. It was proposed that I should undertake the work, and the suggestion was made that, in addition to research in Crete, preliminary studies in the museums at Athens should form part of the programme, which thus included the following series of observations :—

(*a*) On the prehistoric human remains in the museum at Candia and in the ossuary at Palæokastro, Crete.

(*b*) On the physical characteristics of the modern Cretans, and

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especially those of the province of Sitia (the country inhabited anciently by the Eteo-Cretans).

(*c*) On the ancient human remains in the Athenian museums.

(*d*) On the physical characteristics of the modern Greeks.

I then applied to the Committee of the British School at Athens for admission as an Associate of the school, and a further application was made to the Committee on my behalf for a sum of money in aid of the work. The former application was granted, but the response to the latter was coupled with conditions which I did not see my way to accepting.

I arrived in Athens on January 12, 1903, and was introduced by the Director to Professor Stephanos, who, as Curator of the anthropological collection in the Academy at Athens, was in a position to enable me to enter on that portion of the work which dealt with the physical anthropology of the ancient and modern inhabitants of Greece. As regards this, Professor Stephanos at once stated definitely that he himself had abundant materials in hand and on the point of publication for an exhaustive monograph dealing both with ancient remains and modern inhabitants.

I thus discovered that my time would be more profitably spent in examining the material in the National Museum under the charge of Mr. Stais. Thereupon I commenced work in that museum, examining particularly the human remains from the shaft-graves at Mycenæ, and the skulls from the Theban monument on the battlefield of Chæronæa.

A fortunate chance, for which I am indebted to Mr. Tod, of the British School, enabled me to measure a number of persons in the reformatory. This, with occasional visits to the collection of crania in Professor Stephanos' charge, completed the work I was able to do in Athens.

Arriving in Candia on February 28, 1903, I at once commenced work in the museum on the crania brought from Palæokastro in 1902 by the Director of the British School. This work, with measurements of the whole of the police force of Candia, occupied me till it was possible to proceed to Palæokastro, for which place I started on March 15, in company with Mr. Dawkins, student of the school. Through the courtesy of Professor Halbherr and his assistant, Dr. Paribeni, of the Italian mission, I was able to measure a number of workmen at Vori, near Agia Triadha, and also to measure men of the police force at Vori and Pyrgos. Arriving at Palæokastro on March 25, work was resumed on the mound occupied by the ossuary partly excavated in 1902. This collection of skeletons was completely cleared out in the next ten days, and work was then commenced on a neighbouring hillside on a site known as Patema, where preliminary excavations had revealed skulls in 1902. A week sufficed to collect all the material from this site, which will be remarkable for having furnished an example of the mode of interment practised, an almost complete skeleton having been discovered in the contracted position and on the left side.

In the next place two days were spent in excavating rock-shelters near Agios Nikolaos, after which work was resumed near the original ossuary (near Roussolakkos, Palæokastro). There was then discovered a second ossuary near the first, but of much smaller dimensions, and the whole of this was completely excavated by the afternoon of April 11.

Opportunities for measuring living Cretans had occurred both at the excavations, also at Angathi and at Adrovasti, a village some eight miles away.

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On my way back to Candia I visited (in company with the foreman of the excavations at Palæokastro) the inland villages of Khandra and Armenos, in the Præsos district, and here a number of men were measured.

Returning to Candia on April 15, I journeyed to England *via* Athens and Constantinople, spending a few hours *en route* in inspecting the collections at Buda-Pesth and at Vienna, the latter being remarkable as containing the very extensive collection of modern Greek crania formed by Dr. Weisbach.

In addition to the observations on adult Cretans I made observations on and measured 100 school children in the island.

In terminating this report I desire to express thanks to several persons, and in the first instance to the Director of the British School; also to Messrs. Tod and Dawkins, students of the school. Professor Stephanos gave me a valuable letter of introduction in Crete. Professor Halbherr and Dr. Parabeni gave me valuable help as already described; Commandant Borgna (chief of the police force of Crete) gave me facilities for work which would have been impossible but for his aid. Space does not admit of further mention by name of those who assisted me at various stages, but I hope to acknowledge their help in the course of future publications.

PART II.—*Special Reports.*

Reference to the general report will show that the observations fall under the four headings following :—

(*a*) On the prehistoric human remains in the museum at Candia and in the ossuary at Palæokastro, Crete.

(*b*) On the physical characteristics of the modern Cretans, and especially those now inhabiting the province of Sitia, the ancient habitation of the Eteo-Cretans.

(*c*) On the ancient human remains in the Athenian museums.

(*d*) On the physical characteristics of the modern Greeks.

As these reports prove to be of considerable length, it is proposed to submit here brief notices of the general results of the investigations.

Special Report (a).—On the Prehistoric Human Remains in the Museum at Candia and in the Ossuary at Palæokastro, Crete.

As already mentioned, the site of the excavations which provided the human skeletons is a low mound in the vicinity of the ancient (Minôan) settlement at Roussolakkos, Palæokastro. The position and main features of the ossuary have been already described by Mr. Bosanquet,[1] by whom the site was partly excavated in 1902.

Low stone walls surround a quadrilateral inclosure divided by partitions into five compartments within which hundreds of bones were amassed in confusion, which was not, however, absolute, for although bones of the feet might be found impacted in the orbits of skulls, yet a general survey showed that on the whole the skulls lay in distinct groups apart from the limb bones, which were often stacked. This arrangement and the comparative scarcity of the small bones of wrist and foot show clearly that the skeletons had not been primarily interred here, but

[1] Cf. *Man*, 1902.

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that the bones had been transferred from some other cemetery or graves, and thus the term 'ossuary' is advisedly applied to the locality.

This circumstance was attended with advantages and disadvantages, for while the bones were so closely packed that a comparatively small amount of labour brought many examples to light, and thus saved much time that would have been consumed in exposing each skeleton if separately interred, yet the disadvantage remained that it was rarely possible to assign a number of bones to the same skeleton, and there is thus a certain lack of information as regards the proportions of the limbs. The condition of the bones was unsatisfactory as regards transport, their substance being extremely friable: this necessitated great care in excavating, and measurements could often only be made while the bone or skull was still half imbedded in the soil. About thirty-five skulls and two or three hundred bones were preserved in various ways, but the results of these attempts are not yet available.

Including the skulls discovered in the rock-shelter at Agios Nikolaos, there were altogether about a hundred skulls available for examination. In the case of male skulls sixty examples, and of female skulls twenty-two specimens were actually measured. Skulls of later date were found in the museum at Candia, including skulls from Zakro, collected by Mr. Hogarth; a child's skull was found at Agios Nikolaos; and several modern Cretan skulls were also measured.

We are now chiefly concerned with the sixty-two male and twenty-two female skulls from Palæokastro. To these may be added the data referring to two male skulls and one female skull obtained at the same place in 1902 by Mr. Bosanquet, and measured by Dr. Myers at Cambridge. This brings the total to sixty-four male and twenty-three female crania.

The important feature to notice here is the breadth or cephalic index of these crania, which is on the average 73·4 for males and 73 for female skulls; both are therefore dolichocephalic. The specimens are thus concordant in this character with the majority of other early Cretan skulls and, it may be added, with most early Greek crania from the mainland.

But an important point (upon which information was desired by many who are interested in the prehistoric ethnology of Greece and the Levant, including Crete) is the inquiry as to how far this character of long-headedness is general among this early population, and is not merely the expression of an average.

In the scanty material previously available, short (brachycephalic) skulls are admittedly infrequent, and the accession of comparatively abundant new material provides a fresh contribution to our stock of information. The result of the investigations is, then, to show that in this early Cretan population longheadedness is quite predominant: of forty-six male crania available for examination thirty (65·3 per cent.) are dolichocephalic, twelve (26·15 per cent.) are of mean proportions, and only four (or 8·55 per cent.) are short. The corresponding percentage figures for female skulls are 70·6 dolichocephalic, 23·53 of mean proportions, and 5·87 per cent. of short skulls.

Such a proportion of short skulls had previously been anticipated by some (certainly by Mr. Myres), and it is evident that a proportion of 8 per cent., or even 5 per cent., in a population constitutes a factor that cannot be ignored in a full discussion of race affinities.

It remains to be remarked that the crania here described are almost

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certainly of greater antiquity than those from Zakro described by Boyd Dawkins in 1902, and than those from Erganos described by Sergi ; and, further, that the fact of long and short crania being found associated in the same ossuary is more weighty in evidence than when (as heretofore) short crania found in one ancient locality have been described as contemporaneous with long crania found in a different place.

The long bones afford an estimate of the stature of the early inhabitants of Palæokastro, which would seem to have been approximately 1624·9 mm. for men (below 5 feet 5 inches). This is a distinctly low stature, and the bones are slight.

It thus appears that in head-form and stature these early Cretans anticipated the conformation of the Mediterranean race, as the precursors of whom they can be provisionally described.

Reference must be made particularly to the most important discovery at the site known as Patema, of a skeleton (without the skull) lying in a contracted position and on the left side, like the skeletons of the New Egyptian race at Naquada. The long axis of the body was approximately N.E. and S.W., the head having been to the east.

Such are the main results of the investigations included under special report (*a*).

Special Report (*b*).—*On the Physical Characteristics of the Modern Cretans, and especially of the Inhabitants of Sitia, the ancient habitation of the Eteo-Cretans.*

This report falls into two sections, the first of which deals with adult male Cretans and the second with school children of both sexes.

Section (i.) The results of most importance refer to the proportions of the head and to the stature, these being the points upon which information was chiefly desired as a basis for the comparison of ancient and modern Cretans.

Taking the proportions of the head first, a most striking result has come to light, viz., that in Eastern Crete the modern head-form is totally different from the prehistoric as deduced from the material at Palæokastro. In the province of Sitia not only is the average head short (brachycephalic), but this is the most frequently occurring form. At the same time the stature of the men has increased markedly since the Minôan period.

The second point of importance is that in certain provinces of Crete the ancient form of skull is evidently still preserved. It may be noticed that data were obtained from no fewer than seventeen out of the twenty provinces of Crete, but that the material for Sitia, in the eastern part, is much more abundant than that from any other district.

These facts will, it is believed, furnish the basis for much discussion, a difficult point being the explanation of the modern predominance of short-headed men in Eastern Crete, the region which was considered as perhaps the least subject to invasion and admixture. Here it can only be remarked that records exist of definite colonisation from Venice, and that, considering the preponderance of short heads among modern Venetians, the solution may lie in an appeal to this historical factor.

Turning to other observations on modern Cretans, it will suffice to state that while in colour of the hair the darkest shades are the commonest, this is not the case as regards the colour of the eyes, the most

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frequent tint being the intermediate one known as hazel. Two instances were noticed of undoubted Cretans with fair hair and blue eyes of the North European blond type : the brother of one of these blond men was dark with dark eyes. These brothers, with their parents and grandparents, were inhabitants of Angathi (Palæokastro).

Up to the present time I find myself unable to adduce instances of men reproducing in features and complexion the type represented on the Knossos frescoes, but would suspend further comment till other districts have been seen.

Section (ii.) The school children.

Seventy-nine boys and twenty-five girls were measured and examined : the majority of the boys (fifty-nine) and all the girls were observed at Vori (South Central Crete), province Pyrgiotissa ; the remaining boys at Angathi (Palæokastro). It is very interesting to note that in respect of head-form, and dealing only with boys (between whom alone comparison is possible), exactly the same difference obtains between East Crete and South Central Crete as in the case of the adult males, viz., in East Crete the heads are brachycephalic. Hair colour is lighter than among the adults, this being a common phenomenon in all European races ; dark brown is the commonest eye colour among the children, not hazel as among the adults.

The comparatively poor physique of the children was very noticeable, numerous instances occurring in which a boy of fifteen years would have passed as at least four years younger if supposed to be of British parentage and of the better nourished class. Intellectually, however, no inferiority seems to exist.

Special Report (c).—*On the Ancient Human Remains in the Athenian Museums.*

Section (i.) The National Museum.

While no skeletons of such antiquity as those from Palæokastro were seen, yet there are remains, more or less perfect, of several skeletons of the Mycenæan epoch, notably those from the celebrated tombs discovered by Schliemann at Mycenæ. Unfortunately the earlier examination of these skeletons was superficial only, and in the intervening period much disintegration has ensued. The results of a careful examination are therefore as follows :—

From Graves Nos. 1, 2, and 3 (referred to in Schliemann's book as Nos. ii., v., and iii. respectively) the fragments are too small to enable one to make satisfactory measurements ; bones of domestic animals are mingled with the human remains.

From Grave No. 4 (Schliemann's No. iv.) there are the remains of the shafts of a perfectly normal femur and tibia (with no marked platymeria or platycnemia) ; also two short slender femora and two radii, these latter and the femora being encircled with gold bands. With these are many animal remains.

From Grave No. 5 (Schliemann's No. i.) came the body which is illustrated in Schliemann's classical work : it has now fallen into a most fragmentary state. Other bones and fragments fill a large tray : they are mixed with animal bones. A massive femur belonged to a tall well-proportioned man of 1,759 mm. stature.

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In Grave No. 6 there were two interments. Fragments of both skeletons remain; the subject of primary interment was a slight man of small stature; the tibia was slightly flattened. The other bones do not afford any certain indication as to the body or bodies secondarily interred.

Other remains of approximately similar date are the female skeleton (stature 1,534 mm.) from Thoricus and a child's skull (index 74·9) from a tomb at Salamis. Of much later date are the nine skulls of the Thebans who fell at Chæronæa: these skulls are either long or of mean proportions, no brachycephalic examples being seen. Other skeletons, three in number, are also in the vase-room of the museum: of the skulls of these two (male) are dolichocephalic, while the third is a short and broad female skull. On the whole, then, brachycephalic proportions are rare among these ancient Greek crania.

Section (ii.) The skulls in the Academy (in Professor Stephanos' charge) include the following:—

(*a*) Ancient skulls from Mycenæ (Tsountas' excavations), Nauplia, Syros, and Paros. These are mostly dolichocephalic; but brachycephalic examples occur with sufficient frequency to call for consideration.

(*b*) Skulls of the 'Dipylon' period, from Eleusis: these are more constantly dolichocephalic than the preceding (*a*).

(*c*) 'Roman' and 'Byzantine' period skulls: these present a variety of form.

(*d*) Recent skulls from Arcadia: these tend more frequently to brachycephaly, and thus agree with the skulls of modern Greeks in general.

(*e*) Recent skulls from Thessaly: these bear out Professor Stephanos' statement that long skulls are more frequent in Thessaly than in other Greek districts at the present day. Artificial deformation occurs in this series, which are of varying dates during the last two centuries.

(*f*) A collection of recent skulls from the Ægean island of Thera comprises certainly one definitely brachycephalic skull.

Special Report (d).—On the Physical Characteristics of the Modern Greeks.

The contribution to this subject consists in the collection of data relating to about a hundred inmates of the reformatory for male juvenile offenders at Athens. On the theory that criminals are a selected class, it may be objected that such observations are inadmissible, or that they have no value as evidence of the conformation of the normal members of the population. In answer to such objections it is submitted that the majority of those persons observed were undergoing detention for 'first offences,' so that they need not be regarded as habitual offenders, who may possibly form such a select type or class as has been referred to.

The measurements of the heads of these youths (for their ages ranged from about fifteen to twenty-five) yield averages which in turn afford an index of 82·04, so that on the average the head-form is brachycephalic. Not only is this the characteristic of the average example, but no less than 73·6 per cent. of the individuals presented this feature (24·3 per cent. mesaticephalic, 2·1 per cent. dolichocephalic). Some photographs of the vertex view of the head show the rotundity in a striking manner. The foregoing result corroborates the results arrived at by earlier observers, but

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differs from the results obtained for Greeks of Asia Minor, for in the latter[1] a very distinctly dolichocephalic element is present, and in the Greeks of the mainland this element, though not entirely absent, is so feeble as to be almost negligible.

In respect of hair colour the predominant tones are the darker shades of brown and jet-black. The most frequent eye colours are : dark brown, 38·5 per cent. ; and hazel, 35·9 per cent. respectively.

A comparison of these results with those published by other investigators leads to the conclusion that the individuals observed may be regarded as fairly typical ; and a comparison with the modern Cretan results—report (*b*)—shows that while the modern head-form in Crete varies between extremes of dolichocephaly and brachycephaly, and that the modern Cretans on the whole have rather longer heads than modern Greeks of the mainland, yet in some respects the modern Eastern Cretans surpass the modern Greeks, having shorter heads than these.

While the hair colour forms but a slight basis for contrast between the same modern stocks which closely resemble each other in this respect, the evidence of the eye colour is to the effect that while the hazel tint predominates (40·5 per cent.) in Crete the chief place in point of frequency in Greece is shared by eyes of this colour and by dark-brown eyes, so that the modern Greeks of the mainland are more decidedly brunette than are the modern Cretans.

Lastly, when the proportions of the skull are considered (correction being made where necessary for head measurements) it will be noticed that on the whole modern Greeks and modern Cretans differ from their prehistoric predecessors in the same way, viz., that the head-form, which was previously elongated, has become very much shorter. For this comparison of the prehistoric and the modern populations the material dealt with in special reports (*a*), (*b*), and (*c*) is now available, in addition to that forming the subject of the present section.

Such a conclusion has no doubt been anticipated, but it is submitted that the confirmation derived from a wider study will not be without value.

Concluding Remarks.

The foregoing notes constitute a *résumé* of the observations and data made and collected during the limited time available for research. As regards the special object towards which the Committee devoted the grant, it is pointed out that the local change in physical type has been very great indeed since the settlement at Roussolakkos was flourishing. In head-form in particular the change has been marked ; but this effect has not been uniformly produced, though the eastern part of Crete has been particularly influenced. On the other hand, the data from other provinces include some which suggest strongly that the search for modern representatives of the Minôan population of Eastern Crete must be diverted from Sitia, and that other localities may have escaped from the action of influences which have acted powerfully in the eastern province, inaccessible though it was believed to be. The present reports can therefore only be regarded as instalments, and it is believed that further efforts would be richly rewarded.

[1] *Cf.* v. Luschan.

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Silchester Excavation.—Report of the Committee, consisting of Mr. ARTHUR J. EVANS (*Chairman*), Mr. J. L. MYRES (*Secretary*), *and* Mr. E. W. BRABROOK, *appointed to co-operate with the Silchester Excavation Fund Committee in their Excavations.*

THE excavations in 1902 were begun on May 15, and continued without break until November 17, under the direction of Mr. Mill Stephenson.

To suit the convenience of the tenant, operations were for the most part confined to a narrow and irregular-shaped field of some four acres in the south-east quarter of the town, adjoining and lying westwards and southwards of the present churchyard.

The area in question consists as to its northern half of a gentle slope southwards, but it then rapidly descends, and its southern end is only slightly raised above the level of a small brook which rises close by.

The eastern margin of the field was explored in 1890, when part of a walled enclosure, containing two square temples, which partly underlie the churchyard, was excavated and planned. A small corridor house to the south of the temple enclosure was discovered in 1896, when the ground there was explored in view of an extension of the churchyard.

The operations of 1902, for the reasons above cited, did not enable the executive committee to excavate any entire *insula*, but portions of at least four were included in the area placed at its disposal.

The first work undertaken was the tracing of the temple boundary wall northwards. This was followed up to and across the modern road crossing the town and into the field beyond. Here it was found to turn at a sharp angle in the direction of the east gate, thus showing that the main street through the town from west to east was deflected from a straight line before passing out eastwards. At the upper corner of the temple area was uncovered a small apsidal building of uncertain use.

The buildings of which remains were uncovered in the field adjoining the churchyard were eleven in number. They included five more or less complete houses, and as many other structures. Two of the latter are of a character not hitherto found at Silchester: one being a semicircular building entered probably by a wide arch, and forming a kind of alcove; the other a long narrow gallery with a colonnade or portico along one side. Both buildings may have stood in a pleasure garden belonging to the house found in 1896 south of the temple enclosure.

Besides the field next the churchyard, the exploration was undertaken of a section of the pasture west of it. This brought to light two more houses and two other smaller structures, one perhaps a group of three shops. The houses belong to the *insula* (XXVIII) south of XXVII, which was explored in 1901.

The several houses discovered in 1902 are of interest, firstly, for their comparatively small size, and secondly, on account of the transition from the corridor to the courtyard type which most of them present. Three at least of them had winter rooms warmed by hypocausts, but in two instances the heating arrangements had been cleared out and the rooms put to other uses.

The number of buildings in the circumscribed area dealt with left comparatively little space between for garden ground, and consequently the number of pits and wells and of objects found was unusually small.

Part of a large inscribed slab, with remains of finely cut letters five

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inches high, was found used up as building material in one of the hypocausts in the southern part of the field. A much-mutilated Attic base of good character, and some portions of marble mouldings and wall linings were also turned up in the same quarter. All these may have come from one or other of the temples during its rebuilding or destruction.

Large part of a quern of the unusual diameter of twenty-eight inches, of Andernach lava, was found in another of the trenches. It retains two of the iron loops of the machinery by which it was revolved.

The smaller objects included a few good brooches in bronze, a torque and a pin of silver, portions of a pane of window-glass, a rod of solder, part of two large trenchers of Kimmeridge shale, as well as a considerable number of coins.

The pits and wells also yielded a quantity of bones of oxen, sheep, goat, and horse.

The search for remains of plants &c. in the filling-in of the pits and wells, which has been pursued with such conspicuous success during the last five years, has been continued by Mr. A. H. Lyell. The results have been examined by Mr. Clement Reid, F.R.S., who has identified the seeds of twenty-four more plants not hitherto known to have been introduced into this country so early as the Roman period. Among the plant remains were clippings of box and the seeds of fig and grape.

A detailed account of all the discoveries has been communicated to the Society of Antiquaries, and will in due course be published in 'Archæologia.'

Owing to the limited number of the minor antiquities found last season, it has not been thought worth while this year to have any public exhibition of them.

The Committee proposes during the current year (1903) to continue last year's excavations westwards, with the object of completing the unfinished *insulæ*. The work was resumed in May, and has already brought to light a building of large extent which seems to be the long-sought-for public baths of the town.

Looking back over the course of the excavations hitherto, the Committee ventures to suggest that the opportunity should be taken, in exploring the small fraction of the site which remains, to make special and detailed observations on certain points which do not yet seem to have been made out definitely. The following are suggested as specially worthy of attention :—

(1) Though the architectural history of Silchester has been elaborated in great detail, very little evidence has been recorded hitherto as to the stratification and sequence of the smaller finds, and as to the question whether any parts of the site were occupied only at special periods, or whether (as would appear from the published reports) there is practically only one stratum of remains on the whole of it. A closer registration of the contents of the numerous pits and wells, and of the areas which are still covered by undisturbed pavements, would probably go far to settle this point.

(2) The relation in which the rectangular street-plan stands to the trapezoidal wall-plan of the town has not yet been made clear at all points, and might easily be elucidated in the course of the next few seasons' work, by minute study of mound, wall, and ditch ; as well as by confirmatory trenching to greater depths at the points where the street-lines, if produced, would intersect the line of the wall.

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To facilitate the investigation of these and similar points the Committee asks to be reappointed, with a further grant.

[N.B.—As the outcome of discussion of this Report, a reconstituted Committee was appointed at the Southport meeting with enlarged terms of reference—'To Co-operate with Local Committees in Excavations on Roman Sites in Britain.']

The Lake Village at Glastonbury.—Fifth Report of the Committee, consisting of Dr. R. MUNRO (*Chairman*), Professor W. BOYD DAWKINS (*Secretary*), Sir JOHN EVANS, Mr. ARTHUR J. EVANS, Mr. HENRY BALFOUR, Mr. C. H. READ, *and* Mr. A. BULLEID.

THE Committee, reappointed at the last meeting of the British Association at Belfast, and specially instructed to ascertain the best method of completing the exploration as quickly as possible, and of publishing the results with the least possible delay, reports as follows:—

The work which remains to be done in the exploration of the lake village is comparatively small, and consists of the examination of twelve huts with the circumjacent areas, out of a total number of seventy-six huts within the palisades, which define the site of the village from the urrounding marsh. This will be taken in hand in the course of the next year, as the dryness of the season may permit. If it cannot be finished in one, it will be carried on in the next season, and it will be completed.

Since the last Report of the Committee at the Dover Meeting in 1899, the exploration carried on by Mr. Bulleid has been stopped, owing to his unavoidable absence. One hut, however, has been explored by the Archæological and Natural History Society, under the supervision of their Assistant Secretary, Mr. Gray. This has been described and figured by him in the Transactions of the Society for the year 1902, in a paper that is a valuable contribution to our knowledge of the lake village.

It is proposed that the future work should be carried out under the supervision of the following gentlemen, who will act in agreement with this Committee: Mr. A. Bulleid, as representing the Glastonbury Antiquarian Society, and Mr. St. George Gray, to whom the Somerset Archæological and Natural History Society has offered special permission to assist in the work. In this manner the continuous supervision of the work, so necessary in explorations of this kind, will be adequately provided for.

With regard to publication, the Committee is of opinion that a report of the progress made in each session should be prepared for the British Association by the superintendents of the work, until it is completed. When it is completed the general results of the exploration should be published, with adequate illustration by the superintendents, and edited by a Standing Committee of the Association. The precise form which the publication should take may be left for decision until the exploration has been finished.

In this manner, and with a grant in aid of the exploration fund by the British Association, the Committee believes that this—the most important archæological investigation now going on in the British Isles—will be rapidly finished, and that the results of the work which has been going on for ten years, so long expected, will be published with the least possible

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delay. The exploration on these lines has received the sympathetic support of the county of Somerset, and of those outside the county who are interested in the social state of Britain in the centuries immediately preceding the Roman Conquest.

Pigmentation Survey of the School Children of Scotland.—Report of the Committee, consisting of Mr. E. W. Brabrook (*Chairman*), Mr. J. Gray (*Secretary*), Dr. A. C. Haddon, Professor A. Macalister, Professor D. J. Cunningham, Mr. J. F. Tocher, *and* Dr. W. H. R. Rivers.

The progress made by the Scottish Ethnographic Committee with this survey during the past year has not been so great as was anticipated in the last report. The delay has been principally caused by the difficulty experienced in getting lithographed colour cards to be used as colour scales for hair and eyes. It was considered that precise and reliable statistics could not be obtained from a number of different observers, except a standard colour card was sent to each. About twenty different shades of hair were collected and an equal number of glass eyes. These were sent for reproduction to a photo-lithographer, but after repeated attempts he failed to get a satisfactory result by direct photography. The shades have now been copied successfully in oil colours, and it is hoped that these copies can be successfully reproduced by lithography. The proofs are expected to be ready at an early date.

The application for co-operation to the Educational Institute of Scotland has been very successful, this association, whose assistance is so essential to the success of the survey, having passed a resolution recommending the teachers to supply the information desired by the Committee.

The subdivision of Scotland into 110 numbered districts has now been completed. As soon as satisfactory colour cards have been received the schedules will be sent out and the survey carried out as rapidly as possible.

The Psychology and Sociology of the Todas and other Tribes of Southern India.—Report of the Committee, consisting of Professor Ridgeway (*Chairman*), Dr. W. H. R. Rivers (*Secretary*), Dr. A. C. Haddon, *and* Mr. W. Crooke.

On reaching India Dr. Rivers first visited two hill tribes with Mr. Edgar Thurston, to whom he owes many thanks for help during his visit to India. These tribes—the Sholagas and Uralis—live in the jungle in hills in the northern part of the Coimbatore district, and while Mr. Thurston investigated the physical characters and the customs of the people Dr. Rivers devoted his attention to psycho-physical work, of which an account will shortly appear in the 'Bulletin of the Madras Government Museum,' edited by Mr. Thurston.

The remainder of his visit to India was devoted to the Todas of the Nilgiri Hills, though a few observations were made on members of two other tribes inhabiting the hills—the Kotas and Badagas. The psycho-physical work was carried out on the same lines as those described in the Reports of the Cambridge Anthropological Expedition to Torres Straits, vol. ii. parts i. and ii. Over 500 Todas were examined and a large number of observations made which have not yet been fully worked out.

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Much time was devoted to the study of the sociology and religion of the Todas. It was found that genealogies were preserved, and the pedigrees of over seventy families were collected. Largely by their means a detailed study was made of the social organisation, system of kinship, and regulation of marriage.

Much attention was devoted to the details of the ritual of the Toda dairy, which was found to be of a definitely religious character. Many other ceremonies were recorded, and whenever possible witnessed. These include ceremonies performed during pregnancy and after childbirth; ceremonies performed when naming and piercing the ears of children; ceremonies performed when men are fined for any offences against the dairy; the well-known prolonged funeral ceremonies; ceremonies of animal sacrifice and of lighting fires on certain hills.

It is intended to publish shortly a full account of the ceremonies and of the general results of the investigation of the sociology and religion.

Botanical Photographs.—Report of the Committee, consisting of Professor L. C. MIALL (*Chairman*), Professor F. E. WEISS (*Secretary*), Mr. FRANCIS DARWIN, Mr. G. F. SCOTT-ELLIOT, *and* Mr. A. K. COOMÁRASWÁMY, *appointed to consider and report upon a scheme for the Registration of Negatives of Botanical Photographs.*

A LEAFLET giving information regarding the collection, preservation, and systematic registration of photographs has been prepared by the committee appointed at Belfast, and has been distributed by the Secretary of the Association to all the Corresponding Societies, together with blank registration forms. The same pamphlet and form were also sent to a number of private individuals interested in botany and photography, and it is hoped that as a result a number of photographs taken during the summer months will be sent in for registration. Up to the present some fifty or sixty have been received, of which a considerable number are suitable for registration. The grant to the Committee has been sufficient to defray the expenses of purchasing cards and printing forms and cards for registration, but insufficient to provide mounts for the photographs. It is hoped that this may be done out of next year's grant.

The Committee desire to be reappointed, with a grant of 5*l*.

LEAFLET ABOVE REFERRED TO.

Botanical Photographs Committee.—Professor L. C. MIALL, *F.R.S.* (*Chairman*), Professor F. E. WEISS, *D.Sc.*, *F.L.S.* (*Secretary*), FRANCIS DARWIN, *F.R.S.*, A. K. COOMÁRASWÁMY, *F.G.S.*, *and* G. F. SCOTT-ELLIOTT, *B.Sc*, *F.L.S.*

This Committee was appointed by the British Association for the Advancement of Science at its meeting in Belfast in 1902 for the purpose of arranging for the 'Collection, Preservation, and Systematic Registration of Photographs of Botanical Interest.'

A similar committee was appointed in 1889 to collect and preserve photographs of geological interest, and in 1898 a committee was appointed to collect and preserve photographs of anthropological interest.

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The considerations which led to the appointment of these committees were briefly as follows :—

1. Many naturalists and travellers find it necessary to make photographic negatives in the course of their work for which they themselves have no further use, but which they would gladly make accessible to other students if any scheme existed by which this could be done without much trouble.

2. Further, though many professional photographers in various parts of the world have made use of their opportunities of recording various types of vegetation, there has hitherto existed no record of what has been done in this direction; with the result that valuable collections have remained unknown or inaccessible to those in whose interest they have been made.

What appears therefore to be required is, in the first place, a register of the photographic negatives which can be made generally available, illustrated by a permanent print from each, preserved in an accessible centre. It is also essential that properly qualified students may be enabled to obtain duplicate prints, or lantern slides made from them, for their own use at a reasonable price. In any such scheme it would be understood that the copyright, for purposes of publication, would remain with the owner of the negative, and that all duplicate prints or lantern slides distributed under this arrangement would be subject to that qualification.

In establishing such a register the Committee desire the co-operation of all owners of suitable photographic negatives, who are invited to submit for registration one print from each negative, together with full particulars of the subject of the photograph on the enclosed form (Form A), additional copies of which can be obtained from the Secretary of the Committee.

It will be found convenient for the sender of the photograph to number it on the back and to fill in this number on the printed form.

Photographs should be sent *unmounted*. This is essential in order to secure the proper systematic arrangement of the collection. They will be mounted by the Committee on cards of uniform size.

Copies of photographic prints, and information relative thereto, should be sent under cover to the Secretary of the Committee *at the earliest* possible date in order to facilitate the work of registration. They should be sent not later than August 1 in each year.

A detailed list of the photographs officially received each year with the names of the donors and information as to where copies may be obtained will be inserted in the report of the Committee, which is presented annually to the British Association. A copy of the report will, if possible, be sent to each donor of a photograph.

The photographs will be deposited in some central institution, where they will be accessible to the public for purposes of reference.

It is important that copies of photographs which have been processed for illustrating articles and papers in journals should be deposited in the collection; they should be accompanied by an exact reference to the publication and, if possible, a copy of the plate.

To avoid duplication of photographs the Committee reserve to themselves the right of returning duplicates or unsuitable photographs to the sender without registering the same.

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Recommendations for the Collection of Botanical Photographs.

A. *As to Subject.*—The Committee propose to include the following range of subjects :—

1. Portraits of any species of plant (more particularly foreign plants growing under natural conditions) illustrating habit, natural surroundings, or points of morphological or physiological interest.
2. Diseases or malformation of plants.
3. Photographs of plants raised for purposes of experiment.
4. Photographs illustrating plant associations.

In most cases two photographs would be desirable, one giving a general view of the plant or vegetation and another giving details of the subject.

B. *As to Camera.*—The Committee recommend the use of a whole or half-plate camera, though quarter-plate photographs will be accepted if well defined and clear.

The camera should admit of long extension, so that work at close distances may be possible.

As it is essential that the prints should be permanent, the platinotype process is recommended where possible. The use of isochromatic plates is strongly recommended.

In many photographs the inclusion of a scale object is advisable.

C. *As to Recording.*—In order to preserve the scientific value, each photograph should be accompanied by as many of the following details as can be given on the forms which will be supplied for the purpose, and a copy of which is enclosed :

(*a*) Name of plant and locality, with rainfall of district where known.
(*b*) Special features shown.
(*c*) Date when photographed.
(*d*) Name and address of photographer or of society under whose direction the photograph was taken.
(*e*) Whereabouts of the negative, *i.e.* whether it is retained by owner, or deposited with a professional photographer or with the Committee.
(*f*) Terms on which prints, enlargements, or lantern slides will be supplied.

Further information and additional forms for registration may be obtained from the Secretary of the Committee, Professor F. E. Weiss, Owens College, Manchester, to whom all communications should be addressed

Botanical Photographs Committee. Form A.

Local Number	Size of Negative	Subject, Locality, Date and Special Feature shown	Photographed by	Address at which Negative is deposited	Price of Print	Price of Lantern Slide

This form should be filled in and enclosed with the prints or negatives submitted to the Committee for registration. Additional copies may be obtained from the Secretary, Professor F. E. Weiss, Owens College, Manchester, or from the offices of the British Association, Burlington House, London, W.

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Investigation of the Cyanophyceæ.—Report of the Committee, consisting of Professor J. B. FARMER (*Chairman*), Dr. F. F. BLACKMAN (*Secretary*), Professor MARSHALL WARD, Mr. WALTER GARDINER, *and* Dr. D. H. SCOTT. (*Drawn up by the Secretary.*)

THIS investigation has been continued by Mr. Harold Wager, and is now practically completed. A preliminary paper has been published in the 'Proceedings of the Royal Society.' The following is given by Mr. Wager as a brief summary of the principal results arrived at :—

'The cell contents are divided into two distinct regions: (1) an outer peripheral layer in which the colouring matters are contained, and (2) a central portion which is colourless. Both exhibit a reticulate or alveolate structure, and contain granules of varying sizes. Under certain conditions glycogen is present in the cell, often in considerable quantities.

'The colouring matters, chlorophyll, &c., are contained in small granules embedded in the reticulate network of the cytoplasm. They often appear to be arranged in regular rows, which give the impression of coloured granular fibrils. It is probable that these granules are comparable to the "grana" of ordinary chloroplasts, and not actually to the chloroplasts themselves.

'The central body contains chromatin in the form of minute granules, more or less fused together on a network. This network is not sharply marked off from the peripheral cytoplasm, but it appears to be contained in a vacuole, and at certain times the limiting layer of the vacuole is visible. The central body varies much at different times in the amount of chromatin that it contains. It is more abundant in actively growing healthy cells, in which constant cell division is going on; in such cells a very pronounced and distinct reaction for phosphorus is given when treated according to the methods of Macallum.

'There seems to be no reasonable doubt that this central body corresponds to the nucleus of the higher plants. It is not precisely similar in structure and appearance, but the presence of chromatin, the network-like structure, and the fact that it is contained in a vacuole and is sharply differentiated by reagents from the surrounding cytoplasm sufficiently indicate its nuclear character. We are therefore justified in speaking of it as a nucleus. In the process of division the nucleus simulates in a remarkable manner certain features of the mitotic division of higher plants, but a very careful examination of the whole process in various species of Cyanophyceæ convinces me that it is rather a case of direct division, and not a true mitotic division. Nevertheless it may be justifiable to regard it as a rudimentary form of indirect division. As the cell grows in length the nuclear network becomes drawn out in a longitudinal direction, whilst the chromatin substance appears to become more abundant. The result is in some cases an appearance as of numerous elongate chromosomes lying side by side. The nucleus then becomes constricted in the middle, and divides transversely into two daughter nuclei. At the same time the new transverse cell wall is formed. The formation of the new cell walls appears, however, not to be dependent entirely upon the

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division of the nucleus, as it is not uncommon to find, long before the first division is complete, several new cell walls in various stages of development in other parts of the cell.

'In their cell structure the Cyanophyceæ do not exhibit any very close connection with other plants, except possibly the Bacteria; and even here the affinity does not seem to be a very close one. During the last twelve years I have examined a large number of species of the Cyanophyceæ, and it seems to me that we may regard them as the survivors of an ancient group of chlorophyll-containing plants in which the cell structure presents a more rudimentary condition than in any other group of green plants known to us at the present day, and that, in consequence, their exact relationship to existing plants cannot be traced.'

The Teaching of Botany in Schools.—Report of the Committee, consisting of Professor L. C. MIALL (*Chairman*), Mr. HAROLD WAGER (*Secretary*), Professor J. R. GREEN, Mr. A. C. SEWARD, Professors H. MARSHALL WARD, J. B. FARMER, *and* T. JOHNSON, Miss LILIAN CLARKE, *and* Dr. C. W. KIMMINS.

The Conditions of Profitable Study.—In order to make the most of scientific lessons in school the teacher should have a just appreciation of the relative importance of facts; he should encourage his pupils to work for themselves, and he should adapt his teaching to their present wants. All these requirements have often been disregarded by teachers of Botany.

The Relative Importance of Facts.—In all ages teachers have been blamed for defective appreciation of the relative importance of facts. The term *pedant*, once a mere synonym of *teacher*, has come to mean a man who makes a display of vain learning, while he neglects what is practically useful. Perhaps the teachers of Botany have sinned in this way as conspicuously as teachers of any other sort. Old exercise books survive to show that in one generation instructors were content with getting the classes and orders of the Linnean system committed to memory. In a later generation they chiefly aimed at the description of a plant in correct technical language. Some manuals of Botany of old date are little more than glossaries of terms. Students of Botany have been encouraged to spend most of their time upon the characters by which the British flowering plants are distinguished from one another, the ultimate purpose being apparently a more perfect knowledge of their distribution within these islands. The scientific product of local lists has by no means justified the time and labour bestowed upon them, and their educational effect has been depressing instead of stimulating. Meanwhile the nutrition of green plants, a subject of the highest scientific interest and the very foundation of agriculture, was during many years almost ignored in schools and colleges. So late as 1870 it was very slightly treated in teaching courses, and no Englishman had made any important experiments upon it for a hundred years. It is only of late years that we have become aware that we must study our plants alive and experimentally. Scientific curiosity would surely be better occupied in discovering how plants get their food, respond to stimuli, adapt their structure to new circumstances, contend with their rivals or enemies, and propagate their race than in learning

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Latin names for the shapes of their leaves, or discussing which of many names proposed for a particular species was first used. It will be some guide to the formation of a sound opinion upon any teaching course in Botany to inquire whether the fact that plants are living things is ignored or put in a subordinate place.

It is a mark of the present immaturity of the Nature Knowledge movement that whenever a fresh attempt is made to stimulate the teacher, it is accompanied by a great display of dried plants, diagrams, lantern slides, models, slices of useful woods, lists of species observed, with their dates, and maps of distribution. All these are dead products, and only indicate that someone has been taking pains. Those teachers who fix their attention upon the living plant and its activities will have little need of bought appliances.

The Pupil must Work for himself.—It is probable that most men who have been productive workers in science have at length come to recognise that the best part of their learning they got for themselves. Example and guidance are thrown away upon those who do not make independent efforts; and knowledge accumulated by a mere act of memory is feebly grasped and soon forgotten. It is not by listening to other people, nor by reading their accounts of what they have seen and done, nor by gazing at the pictures which they have drawn, that we make lasting progress in science. The pupil who has been taught thus finds himself master of mere scraps of information, too uncertain for any practical application. He has no power of enlarging knowledge, or of applying old knowledge to new cases, and it is well if he has not acquired a disinclination to carry his studies any farther.

The lecture as a mode of instruction in schools is nearly always bad. It may be a passable expedient where the lecturer meets his audience only once, and is able to suggest to them pregnant thoughts which would have never entered their minds otherwise. But even the occasional lecture is rarely stimulating, and the regular lecture is, especially to young pupils, apt to be flat. We can enliven it a little by questions, especially if the pupils feel free to question the lecturer, but that is not quite enough. Choice and responsibility are necessary conditions of interest, and these are hardly ever conceded to the pupil by any lecturer. There is a better prospect of success when the usual conditions are inverted, and when it becomes the rule for the teacher to listen to his class. Let them explain to him what they have seen and thought; let them draw before him the structures which are under discussion. The explanations and drawings may not be so good as those of a grown man, but at least they are the expression of the thoughts of the learner.

It is practicable, as actual experience shows, to substitute for mere didactic lessons learning by personal inquiry, and it may be doubted whether any single teacher who has made the change has afterwards gone back to the lecture or the lesson book. We have no knowledge of even one such case.

A method of teaching in which every pupil is called upon to take his share has the incidental advantage that it cultivates the power of expression in the class. To be well accustomed to come forward and explain one's meaning without embarrassment, to have learnt how to describe complicated structures neatly, is no small gain to the pupil. In all but quite elementary classes the pupils may be helped, not only to practise the art of expression, but to learn how to use books aright. To search in

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books for the facts which are needed, and then to throw the facts into a new mould, may be excellent discipline for an advanced class. Let the teacher who is not afraid to innovate set before him as his ideal that the class is in future to do for him what he has hitherto done for the class.

In the laboratory it is a good plan to use no book at all, where a whole class works simultaneously at the same things. In biological teaching the abundance of the material, and the simple means of investigation which suffice for elementary students at least, make it possible for large classes to work at the same objects—a great advantage to both teacher and pupils. In botanical and zoological teaching, more than in other scientific courses, it is easy to adopt improved methods, such as that the teacher shall rarely give out information, but chiefly directions and questions, the class observing the object, making drawings and returning answers; that the laboratory work, if separated from the work of the class-room, shall always come first; and that the practical exercises of the students shall furnish the materials upon which the class teaching is founded.

The principle of helping the pupil to work for himself will not be abandoned in the later stages of study. Honours candidates in university or college should spend at least part of their time in original work. Those who are so ill-directed as to read instead of inquiring during their whole academic course lose a great opportunity, that of carrying on a genuine research with the co-operation of a more experienced investigator. To many students the opportunity never recurs.

A Substitute for Class Lectures.—Some years ago lectures were discontinued in the Biological Department of the Yorkshire College. A class of beginners is at first questioned about their recent work in the laboratory. After a few weeks, when confidence has been gained, the students are invited to give more continuous expositions. Several topics (usually five) are written up at the beginning of the lesson, and these are handled by members of the class, called up one at a time by lot. The student whose name is drawn comes forward and treats his topic in his own way, making his own diagrams and answering questions when he has done. The topic on which he speaks is always familiar to him by work which he has already done in the laboratory. If he describes a structure it is one which he has examined and drawn for himself. Inferences and comparisons are often asked for instead of mere facts. In advanced classes more comprehensive topics are proposed, and one student may occupy the whole hour. It is hardly necessary to point out that the teacher must scrupulously avoid harsh criticism. A domineering or sarcastic manner would be fatal to the success of any such method as this.

Inquiry in the Botanical Class. (*By* A. C. Seward.)—A method which I have adopted in dealing with advanced botanical classes may prove useful in a modified form in teaching elementary Botany. After an hour's lecture the students work for two hours in the laboratory. It was during the time devoted to practical work that the following plan was followed. Instead of preparing a common syllabus for all to work through I suggested a separate piece of work to each student requiring six, eight, or more hours to complete. On the completion of each piece of work the student was asked to give a concise account of his results illustrated by blackboard sketches and by numbered sections accompanied by very brief notes. On the conclusion of the short lecture, which usually occupied from ten to twenty minutes, the other members of the class asked

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questions and criticised the statements made by the lecturer. The sections were afterwards examined by all the members of the class, and the preparations made in illustration of each piece of work were kept in a separate tray until the end of the course, when each student was at liberty to appropriate his slides. In an article on Botanical Teaching in University Classes, published in the 'New Phytologist,' January 1901, the above method is described at greater length, and several examples are given in illustration of the system. Since that article was written I have adopted the same plan in a course of lectures and practical work on Gymnosperms. As it was impossible to give a full account in the lectures of all the questions involved in a detailed treatment of this group of plants, I omitted certain portions of the subject, and arranged that these should be dealt with by the students themselves during the practical work. As an example of this method of encouraging students to fill in gaps left by the lecturer, one case may be quoted. X. was asked to make a comparative examination of the anatomy of the leaves of various types of Conifers; in the course of his work he was referred to literature on the subject, and his main object was to discover to what extent anatomical characters may be used in the identification of genera. The account given by X., illustrated by a selected series of his sections, rendered it unnecessary for me to refer to this subject in the lectures. The advantages of the above method over that which I had previously employed were apparent in the much keener interest taken in the laboratory work; the members of the class were in fact engaged in original research, and their attitude was that of investigators who have problems to solve which require thoughtful treatment and careful technique. They entered fully into the spirit of the work, and were stimulated to do their best, partly by the interest which they derived from the work itself and partly from the knowledge that they would be expected to give a clear account of their results to the rest of the class, who were encouraged to ask questions and offer criticisms during the short and informal lecture which the students gave on the completion of each piece of work.

The practice in speaking and presenting facts, the introduction to the methods of research, and the stimulus given by the feeling of rivalry, were, I consider, the most striking advantages of the system.

The Teaching must be adapted to the Needs of the Pupil.—It is characteristic of immature minds that they soon tire. This is a reason for frequently changing the topic and for making the object-lesson the regular mode of teaching Botany in junior classes. Teachers of Botany are not so liable as teachers of chemistry or physics to make the mistake of proceeding from the general to the particular, instead of from the known to the unknown, which is a very different thing. One often recognises the inexperienced teacher by such a phrase as that he intends to begin by consideration of the principles which underlie a particular science. Continuous book and paper work is hateful to children, and their exercises in learning and thinking should be varied with handiwork, their indoor work with outdoor work.

Object-lessons in Botany.—Object-lessons are the best way of instructing children in natural history, childhood being taken to include all ages under twelve or thirteen. In this stage there should be no formal and separate sciences, though the lessons, which are at first studiously varied, may gradually become connected. Among the conditions of profitable object-lessons the following may be noted:—

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(1) Every pupil should have an object to himself, or at least be able to examine the object as long and as closely as he pleases. A drawing is not to be allowed to rank as an object.

(2) Living and growing plants should be frequently observed.

(3) The living plant should not only be studied in flower, but whenever the change of season brings on a new phase of growth, Fruits, buds, and seedlings are as important as flowers.

(4) Experiment can hardly come in too early, and there is nothing else quite so stimulating. Even young children can appreciate the interest of a simple experiment, and they may be allowed to take part in it before they are able to conduct it themselves.

It is discouraging to learn from advertisements in the educational papers what facilities are offered for scamping the object-lesson. The teacher is encouraged to buy his objects, to buy his pictures, and to buy his lessons. It is probable that the late demand for nature knowledge has greatly multiplied the number of worthless object-lessons which are given in school. Unless the teacher regularly works for himself he is not fit to show others how to work, and no good will come of inducing him to add nature knowledge to the list of subjects in which he offers instruction.

Plant-physiology in the School.—When the age of the pupils and the circumstances of the school favour the regular study of Botany we have to choose among several ways of treating the science, each of which has found zealous advocates. If the decision were left to ourselves we should give a distinct pre-eminence to the study of Plant-physiology, on the ground of its great practical importance and of its special value as discipline when studied systematically. Systematic Botany will soon be found to be a necessary adjunct if scientific precision is to be attained, and other aspects of the study will ultimately find a place in the programme, but function in connection with structure should, we think, be prominent in every part of the school course.

In preparing a scheme of instruction in plant-physiology the teacher will do well to take common objects, which will often engage the attention of his pupils in after life, which can be procured in numbers without much cost or labour, and which can be studied alive under natural conditions. The question of the sufferings of the living objects, which is of the first importance in some other branches of natural history, happily does not concern the teacher of Botany.

We can recommend nothing better for first lessons in plant-physiology than the study of seedlings of common garden plants. A course of lessons on seedlings can be so arranged as to lead the beginner to consider attentively the nutrition of a green plant, the adaptation of the plant to external circumstances, and the development of new parts. The course should also train the manual skill of the pupils. Boxes and the simpler kinds of chemical apparatus can be made in the school. The course should bring in drawing to scale, the graphical representation of experimental results, the care of garden beds, the care of water cultures, and many other practical arts. It ought also to encourage the habit of close observation, the habit of methodically comparing structures which in different plants answer the same purpose, the love of experiment, and the unwillingness (so characteristic of the scientific mind) to accept any conclusion except as the result of an independent and careful judgment. The study of seedlings will lead us to consider starch-formation in the

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green leaf, root-absorption, transport of food material, storage of food reserves, and other branches of the great question of the nutrition of plants. The flower and the functions of its various parts can be studied with interest and profit. Experiments on pollination and on the movements of roots, leaves, and shoots are not too difficult for pupils in school.

School Gardens. (*By* Miss LILIAN J. CLARKE.)—At the James Allen's Girls' School, Dulwich, we have tried for some years, instead of giving information in the Botany classes, to lead the girls to observe, to draw what they observe, to experiment, and to write accounts of their own experiments. In this we have been greatly helped by possessing a garden in which girls are allowed to own plots. The work has grown every year until now more than a hundred girls possess gardens. At first only order-beds were made. The girls were encouraged to own order-beds and to obtain plants for them. Gradually more order-beds were added, and now the most important British orders are represented, two or more beds being sometimes allotted to one order. As far as the size of the bed and the claims of other plants permit, each girl is allowed to grow as many specimens of a particular species as she likes. The owners of order Leguminosæ generally take a great interest in growing sweet peas and ordinary peas and beans, and the owners of order Solanaceæ grow tomatoes and potatoes. Town girls are usually so ignorant of the growth of ordinary vegetables that we encourage our girls to grow many. This year there are in the gardens cabbages, Brussels sprouts, cauliflowers, turnips, peas, broad beans, scarlet runners, spinach, beet, lettuce, potatoes, parsley, parsnips, carrots, &c.

Fruits are valued as well as flowers, so most of the flowers are left to form fruits, and various methods of seed-dispersal are studied, as well as the structure of fruits. A large label is placed in front of each bed, and the name of the order, &c., is painted in white on a black background. In each bed small labels are also used; for it is the rule that to each plant, or clump of plants, must be attached a label bearing the English name. Gravelled paths run in many cases on three sides of the beds, so that many girls can work at the same time without getting in each other's way.

When studying pollination it seemed so necessary that the girls should do some work of their own that beds were arranged in which pollination experiments could be carried on. Some plants are covered with muslin in order to exclude insects, while other plants of the same species are left uncovered. Afterwards the girls find out whether fruits appear on either set. When fruits are found on both the covered and uncovered plants, the number and vigour of the fruits are compared. In some plants the stamens are cut off while the flower is in bud. These pollination experiments arouse great interest, not only in those who happen to be studying pollination, but in girls of other classes. Numbers of plants are grown for the sake of pollination by means of insects. Figwort, snapdragon, foxglove, salvia, monkshood, sweet peas, and deadnettles are found most useful, and clumps of these are grown in different parts of the garden. A class often spends the lesson time in the garden, and is divided into detachments for observation of the visits of insects.

Experiments in assimilation are carried on in other beds, and the girls find out under what conditions starch is formed in green plants. Stencils are placed on some leaves, others are covered with vaseline, and various simple experiments are made while the leaves are still on the plant. The assimilation experiment beds are owned by a few girls only, but many

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make experiments on leaves. In wet weather when we cannot go into the garden we find the laboratory window-boxes useful, as in them pollination and assimilation experiments can be arranged. Most of the Botany gardens are either order-beds, or beds in which pollination and assimilation experiments take place; but there are a few others, for example those in which soil experiments are made. Each year we find that something more is needed in the Botany garden, and each year something is added. Last year climbing plants received special attention, and now the girls own plants climbing by twining stems, hooks, roots, stem tendrils, leaf tendrils, or sensitive petioles.

Lately we have been specially interested in studying trees. It had been a drawback that in studying the structure of buds, methods of branching, &c., we had no better materials than cut specimens or trees seen on excursions. This year there has been planted in the garden a specimen of every common English tree not already possessed by us, and we hope that in future the girls will draw different stages of development of the buds of oak, beech, ash, sycamore, maple, willow, &c., while still on the trees.

Two years ago we thought of making a pond for water plants, but this was judged inadvisable, and instead of a pond in the garden a tank is provided in our new botanical laboratory.

As gardening is not a regular branch of the school work, and no school time is allowed for it, the work must be voluntary; but there are many applications for Botany gardens, and great enthusiasm is shown. The school is a day-school, so digging, planting, weeding, and watering are done in the dinner hour, or in the hour immediately following afternoon school. The practical work appeals to many who would not be interested in books, and in several cases the gardens have been the means of arousing a girl's interest in plant life. In fact, we have found the out-of-door work of such value that we hope to extend it, and allow more and more of the school work in Botany to depend on the observations and experiments made by the girls in their gardens.

Excursions.—The school excursion is highly valued as a means of stimulating observation in the field, but we are inclined to think that for want of attention to details its benefits are often imperfectly attained. Excursions are sometimes wholly unprofitable. The leader stops now and then to pick a flower, names it, mentions, perhaps, some curious feature which it exhibits, pops it into his vasculum, and walks on. Most of the party are not within hearing: they have no part assigned to them, and they bring back nothing more valuable than a few dying flowers, with a fleeting memory of some of their names. On a botanical excursion we ought to remark not only flowers and the peculiarities which distinguish them, but the ripening of fruits, the dispersal of seeds, and defences against scorching sun or winter cold. It is only by visiting the same plant at different seasons of the year that we become acquainted with what may be called its biography. To insure the active co-operation of all the members of the class, we have found it useful to distribute a cyclostyled programme, describing, but not as a rule naming, things which are to be looked for.

Example: A Moorland Walk.

1. Find several plants with rolled leaves.

2. Find a plant whose leaves are converted into spines. Look out for seedlings of the same plant.

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3. Bring leaves of three moorland ferns. Can you find one which has two distinct kinds of leaves?

4. Find a moorland grass with fine wiry leaves. Can you find more than one answering to this description?

5. Find a moss which is very plentiful in swampy parts of the moor. Find another which is plentiful in dry places, and occurs in two distinct forms.

6. There is a low plant on the moor which is now in flower. It grows in large patches, and from some of these patches we kick up dust with our feet, while other patches yield no dust. Bring specimens of each sort.

7. How many years old is the biggest stem of ling which you can find?

The objects brought can be named and discussed at convenient halting-places. The school excursion should have a definite aim lest it degenerate into the raid upon wild flowers. It is a good plan to follow it up within a very few days by a lesson on the same objects.

Collecting.—We have a poor opinion of drying plants as an incentive to the study of Botany. The dried plant is an inadequate substitute for the living and growing plant, and finds its principal use in the authentication of botanical discoveries made in distant lands. The habit of collecting plants for the herbarium may be hostile to close study of the environment, and confirm the pernicious belief that the thing of chief importance is to be able to name a plant as soon as you see it. One lamentable result of the rapacity of collectors is that our native flora has become sensibly impoverished of late years. There is little gain to science by way of compensation. Amateur herbarium botanists have not, in our own time and country, done much to solve important questions of any kind, and they often propagate the misleading notion that rare species are better worth attention than common ones. The rarity of a plant is a reason, not for gathering a flower and drying it, but for letting it alone, unless, indeed, you can accomplish some important and unselfish purpose only by its sacrifice.

The museum, like the herbarium, may easily be perverted from its proper function and made a means of oppressing the intelligence of young persons. A vast multiplicity of objects bewilders instead of stimulating the observing faculty. We do not mean for a moment to disparage museums. They are indispensable to the special student, who, as science advances, demands that the museum shall become ever more complete and more rigidly systematic. But the wants of the specialist and of the schoolboy are so dissimilar that they cannot be met by the same collection. A school will be fortunate if it possesses a few striking objects of nature or art, such as a Roman altar, two or three Greek coins, a fine ichthyosaur, a mammoth's tusk, and the like; but long series of woods, seeds, moths, fossils, and minerals are simply dispiriting to the beginner. Schoolboys can do nothing with them except make inferior copies of the same kind. It ought to be needless to remark that the needs and also the powers of the schoolboy are altogether unlike those of the adult specialist. The specialist attends to few things and seeks to master those in every detail. Precise language and minutely accurate knowledge are indispensable to him. He has chosen his walk of life, and knows that his strength and usefulness largely depend upon his power of concentration. The schoolboy is untrained, and his future vocation often unknown. Now

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is the time for him to learn the scope of various sciences, literatures, and histories. But the workshop routine of the professed botanist may do the schoolboy harm instead of good.

In our opinion both herbaria and museums are indispensable to scientific progress. They have their uses even to children, and many naturalists have begun by collecting. But there are things more advantageous and more appropriate to the first stage of botanical study than the accumulation of a pile of wild flowers, dried and named. School collections, illustrating the dispersal of fruits and seeds, the shapes of leaves in connection with bud folding and exposure of the largest possible surface to light, resistance to drought or cold, &c., may be made to gratify the collecting instinct in a harmless way, and at the same time to promote definite inquiries. It is the mechanical habit of collecting for selfish ends, and without any scientific purpose, that we wish to discourage.

Systematic Botany in the School.—The time to introduce systematic Botany into the school course is the time when the need for it is felt. Good teaching will soon make it desirable that the class should be able to recognise such families as grasses and leguminous plants. The families, introduced to notice one by one and illustrated by fresh examples, soon become interesting, and even children delight in the power to run down the easier flowers. Simple descriptions of the families of flowering plants, in which the Latin words are cut down to a minimum, will greatly promote the attractiveness and intelligibility of early lessons in classification. We have no high opinion of the description in technical language, once so strongly recommended, nor of the filling up of schedules. All this is apt to divert attention from things of greater consequence, and to stupefy the docile, while it alienates pupils of active disposition. One independent observation, one carefully conducted experiment, is worth sheaves of schedules.

The Teacher to devise his own Course.—It is natural that the teacher should seek the help of books in preparing his lessons on plants. Such help only becomes mischievous when he becomes dependent upon others alike for information and method. Servile reproduction of another man's lessons is a proof of incompetence. Not only do we maintain that the language and the selection of facts should be the teacher's own, but we would have him plan his own course of work. The unenterprising teacher may look upon the detailed syllabus as a safeguard, but to a teacher of any spirit it is intolerable tyranny. The low condition of elementary science in our schools is largely due to unwise examining. The detailed syllabus, the worship of technical language, the authoritative enunciation of general principles to pupils who have no knowledge of concrete facts, and the practice—still widespread—of endeavouring to learn a science by heart are largely due to the influence of public examinations. Liberty for the teacher is essential to progress on good lines. How to reconcile liberty with tests of efficiency is a difficult but by no means an insoluble problem.

Microscopes in School Work.—The appliances required for junior classes in Botany are few and simple. Much may be done with common knives, needles, and simple lenses. When the dissection of plants becomes a regular occupation, an inexpensive dissecting microscope such as that sold by Leitz of Wetzlar for 8*s.* will fulfil many requirements. Still simpler home-made stands will answer the purpose. It is good for any teacher who has a mechanical turn to devise his own microscope. To make

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them really useful there should be at least one to every pair of pupils. The compound microscope should never appear in junior classes, and we are inclined to think that it will be best to reserve it for the highest form in a secondary school.

Histological details and a knowledge of microscopic plants are often expected of pupils who have never had the use of a microscope. This inevitably leads to unreal teaching.

Other Teaching Appliances.—Diagrams and lantern slides are often made too much of in school work. They should be mere accessories which have their uses in particular cases. A good teacher will not depend upon them, and will usually prefer the drawing made in class. To make the most of simple means is an education in itself.

The Teaching of Science in Elementary Schools.—Report of the Committee, consisting of Professor H. E. ARMSTRONG (*Secretary*), Lord AVEBURY, Professor W. R. DUNSTAN, Mr. GEORGE GLADSTONE, Sir PHILIP MAGNUS, Sir H. E. ROSCOE, Professor A. SMITHELLS, and Professor S. P. THOMPSON.

DR. GLADSTONE'S death last year, at the age of seventy-five years, has removed one of the most familiar, sympathetic, and welcomed figures from the meetings of the British Association. The services which he rendered to the cause of elementary education, especially in London, although well known to his friends, have yet to be fully appreciated. Elected a member in 1873, he retired from the School Board for London only in 1894; throughout this time he was one of its most active members, making himself specially prominent as an advocate of spelling reform, of object-lesson teaching, of manual training and of the teaching of Elementary Science. Perhaps the most enduring testimony of the interest Dr. Gladstone took in elementary education is afforded by the unbroken series of reports, commencing in 1881, presented by your Committee. These reports were almost wholly inspired by him, when not his actual work; to those who knew him, their generally hopeful, indeed optimistic, tone affords good evidence of his guiding hand. The influence which he exercised on the London School Board—the value on such a body of even a single staunch advocate of a policy—is, perhaps, best shown by the fact that after his retirement the Board soon ceased to maintain the teaching of Science in their schools on the level of efficiency which it was beginning to assume, and only last year woke up to the fact that the subject was one requiring special attention. There could be no better illustration of the haphazard manner in which it has been our custom to conduct education.

It was felt last year that the Committee had in great measure served its purpose—that, in view of the changes which have taken place in the educational policy of the country, if any such Committee were to be again appointed, it should be a new one having a more definite line of action marked out for it. It was, therefore, agreed that a final report should be presented this year. In view of the grievous loss which has deprived them of their Chairman, your Committee feel that they cannot bring their labours to a more fitting conclusion than by calling special attention to the work which will ever serve to recall Dr. Gladstone's services to educational science in connection with the Association.

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Dr. Gladstone first brought the subject of scientific teaching under notice at Sheffield in 1879 in a paper read in Section F (Economic Science), in which he referred to the action taken by the School Board for London. At the same meeting Mr. Moss, clerk to the Sheffield School Board, and Mr. Hance, clerk to the Liverpool School Board, described the steps that had been taken to introduce teaching in Elementary Science into the schools in their districts. Mr. Moss spoke of the need for really good teachers. Mr. Hance described the manner in which demonstrations were given by peripatetic teachers.

Dr. Gladstone and his friends were evidently alive to the difficulties that would arise in judging of the work done in schools, for at the Sheffield meeting a committee was appointed to consider 'whether it is important that H.M. Inspectors of Elementary Schools should be appointed with reference to their ability for examining in the scientific specific subjects of the Code in addition to other matters.'

Mr. Mundella was first Chairman of this Committee, Dr. Gladstone being the Secretary. The report, presented at Swansea, referred to the incapacity of the inspectorate to examine in Science and advocated that steps should be taken to secure the appointment of qualified men. The subsequent neglect of Science in elementary schools is in no slight degree due to the fact that this recommendation was neglected.

The Committee was reappointed at Swansea to report 'on the manner in which rudimentary science should be taught and how examinations should be held therein in elementary schools.'

In their report, presented at York in 1881, after considering the manner in which rudimentary Science was taught, recommendations were made :—

As to object lessons.—That these should be taken into account in estimating the teaching given in an infant school.

As to class subjects.—That these should be given preferably through illustrated oral lessons rather than by reading.

As to specific Science subjects.—That a knowledge of the facts of nature is an essential part of the education of every child and that it should be given continuously during the whole of school life from the baby class to the highest standard. Of course in early years this teaching will be very rudimentary; but by developing the child's powers of perception and comparison it will prepare it for a gradual extension of such knowledge. They consider also that the early teaching must be very general, while the later may be more specific.

Up to the present day this last recommendation has been almost entirely disregarded.

The Committee urged, with reference to the prominence given to English grammar in the Code, that the knowledge of Nature should be put on an equal footing in the schools with the analysis of the mother tongue.

Mr. Mundella had just laid upon the table of the House of Commons certain proposals for revision of the Code; the Committee was, therefore, reappointed in 1881 to 'watch and report on the workings of the proposed revised new Code and of other legislation affecting the teaching of Science in elementary schools.'

Desiring that the knowledge of Nature should be more effectually encouraged as a class subject, the Secretary, at the request of the

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Committee, saw Mr. Mundella, the Vice-President of the Committee of Council on Education. He found him desirous of receiving the views of the Committee. The Committee thereupon agreed upon certain recommendations, which were adopted by the Council of the Association and transmitted to the Education Department. The Government adopted some of these recommendations in whole or in part.

From 1883 onwards the Committee was annually reappointed for the purpose of continuing the inquiries relating to the teaching of Science in Elementary schools. Prior to 1894 it was attached to the Economic Section; in that year and until the foundation of Section L in 1901 it was appointed under the auspices of Section B.

Each year prior to 1901, until the introduction of the Block Grant deprived the Committee of the opportunity, a statistical statement has been made, derived from the Government returns, of the proportion of the children examined in the scientific subjects. These have shown considerable fluctuation; the proportion has never risen above 30 per cent. But there has always been great difficulty in interpreting such returns and they undoubtedly convey far too favourable an impression. To quote from the report of 1901:—'Up to 1890 the Government Code of regulations for day schools was so framed as practically to exclude natural and experimental Science. Schools were at that time limited to two so-called "class subjects," which were specifically defined as "English, Geography, History, and Elementary Science," of which English must be one. Of the other three "Geography" has always been the most popular and "Elementary Science" the least. Hence in the year 1889–90 the number of school departments in which "English" was taken amounted to no fewer than 20,304, while "Elementary Science" was taught in only thirty-two. At that period the instruction in English was almost exclusively confined to grammatical exercises and that in Geography to topographical details. Nowadays both terms are to be understood in a much broader and more scientific sense. At the period above named a free choice amongst these subjects was given, the preponderance of English grammar began to decline and has continued to do so ever since. In 1890–91 the figures for English and Elementary Science were 19,825 and 173 respectively; in 1891–92 they were 18,175 and 788. The table given below will show the comparative figures each succeeding year to 1899–1900. Object lessons were made an obligatory subject of instruction in the three lower standards from September 1, 1896; hence the rapid rise in the two succeeding years. They then became merged into the general term of Elementary Science, and, following the terminology of the Code, may sometimes be included under the head of Geography.'

Class Subjects—Departments	1892–3	1893–4	1894–5	1895–6	1896–7	1897–8	1898–9	1899–1900
English	17,394	17,032	16,280	15,327	14,286	13,456	13,194	12,093
Geography	14,256	15,250	15,702	16,171	16,646	17,049	17,872	18,632
Elementary Science . .	1,073	1,215	1,712	2,237	2,617	2,143	21,301	19,998
Object Lessons . . .	—	—	—	1,079	8,321	21,882		

When the character of the work which has been done is considered, the progress made is undoubtedly unsatisfactory. It is beyond question that 'Science' has in no way taken its proper place in our system of

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elementary education. Here and there work of the very greatest value has been done; but such cases are all too rare.

There are many and obvious reasons for the failure. Pupil teachers, as a rule, have received no proper instruction in the subject and, with few exceptions, the training colleges have done little to promote rational methods of teaching the elementary principles of Science and their application to common life. The inspectorate have had but little sympathy with such work and the Education Department itself long took no interest in the subject. The School Boards also have given little help, owing to the fact that they have rarely counted among their members men able to understand the great importance of training in scientific method. In so far as the work has prospered at all, it has been mainly under the ægis of the Science and Art Department; but by placing a premium on certificates they have done much to discourage other than superficial knowledge of individual subjects in teachers. Unfortunately the requirements of the Science and Art Department with reference to specific subjects have rarely been such as to encourage a class of work suitable for elementary schools. A protest from this point of view against the inclusion of specific science subjects in the Code was made by the Joint Scholarships Board in 1897 in a memorandum forwarded to the Vice-President of the Council. The principal recommendation was as follows[1]:—'That in order to place "Science" on a sounder footing in Elementary Schools and, above all, in order that the teaching of the subject may be of real value educationally, it is desirable that only one Science subject should be taught up to and within the Sixth Standard, and that the course should be a progressive one. It seems that this might be accomplished by adopting exclusively Course H given in the Supplement to Schedule 2 of the Day School Code.'

Unfortunately no effect has yet been given to this recommendation by the Education Department.

There can be little doubt that the most effective experiment yet made is that carried out under the London School Board in the Tower Hamlets and Hackney districts by Mr. Gordon and then by Mr. Heller. Although the London Board failed to understand the great work done under its auspices and made no proper arrangements to carry it on when Mr. Heller quitted their service in 1897, it has been appreciated by others, especially by the late Professor FitzGerald and his colleagues on the Commission on Manual and Practical Instruction in Primary Schools in Ireland. In fact, since 1900 Mr. Heller has been engaged as Head Organiser of Science Instruction in Irish Elementary Schools. The system developed in London schools is therefore in full force in Ireland[2] and it is to Ireland that we must now look for guidance.

The great obstacles to good Science teaching at the present time in elementary schools are still, in the words of the report of 1895:—

[1] *Report*, 1897, p. 291.

[2] The subject—General Elementary Science—has been made a compulsory part of the curriculum of national schools and the conditions of object lesson teaching have been carefully defined. Satisfactory laboratory instruction must be given to all students in training colleges. In 1901 the Commissioners of National Education ordered that 'the entire inspection staff' should undergo a course of training in laboratory work and the methods of experimental inquiry. Mr. Heller was originally appointed only for five years; his appointment has recently been made a permanent one, however.

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1 Large classes.
2. Multitude of subjects.
3. Insufficiency of the training course for teachers in Science subjects.
4. Effects of the old Science and Art system, which is clearly far too formal and pays far too little attention to ordinary requirements.

In girls' schools the teaching of Domestic Science and Domestic Economy is gradually assuming importance, but it is to be feared that the course is rarely of a satisfactory character, being far too formal and inelastic, besides lacking a proper scientific basis.

The same may be said of Nature Study. There is a danger that education authorities, realising the value, as a training and as a matter of interest, of 'Nature Study,' will force instruction in this subject in schools in which the teachers are quite unable to handle it effectively by reason of their want of scientific training and knowledge.

Lastly, it should be pointed out that your Committee has always taken a deep interest in manual training. At Southport, in 1883, a recommendation was passed that this Committee 'be requested to consider the desirableness of making representations to the Lords of the Committee of Her Majesty's Privy Council on Education in favour of aid being extended towards the fitting up of workshops in connection with elementary day schools or evening classes and of making grants on the results of practical instruction in such workshops under suitable direction and, if necessary, to communicate with the Council.' In 1885 the Committee reported to the Council that they did consider it desirable to make representations to the Education Department. The Council unfortunately missed an opportunity, as they did not see their way to proceed further in the matter.

Since then manual training has acquired considerable importance in elementary schools: the introduction of such work was in no small measure due to the activity of two members of your Committee, Dr. Gladstone and Sir Philip Magnus, on the Joint Committee of the City and Guilds of London Institute, the Drapers' Company and the School Board for London. There is little doubt that the educational value of this subject has not yet been sufficiently appreciated and that the time is now come to introduce broader conceptions and largely extend it.

In view of the national importance of developing the scientific spirit in elementary schools, it is not too much to say that it is now the duty of the Association to intervene with constructive proposals which will promote such an object: judging from the great success which has attended the labours of the Committee on the teaching of chemistry in schools and the recent discussion on the teaching of mathematics, there can be little doubt that a general inquiry might now be undertaken with great advantage and that proposals might be made which would be of the greatest value in guiding educational authorities generally. It appears desirable that a special Committee should be appointed to report upon the course of experimental, observational, and practical studies most suitable for elementary schools and generally as to the steps which it is desirable to take to secure proper attention to and encouragement of such studies. All who have paid attention to the subject will probably agree that some organised effort should now be made to extend the teaching of scientific method.

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Influence of Examinations.—Interim Report of the Committee, consisting of the BISHOP OF HEREFORD, Sir MICHAEL FOSTER, Sir P. MAGNUS, Sir A. W. RÜCKER, Sir O. J. LODGE, Mr. H. W. EVE, Mr. W. A. SHENSTONE, Mr. W. D. EGGAR, Professor MARSHALL WARD, Mr. F. H. NEVILLE, Mrs. W. N. SHAW, Dr. C. W. KIMMINS, Dr. H. E. ARMSTRONG (*Chairman*), *and* R. A. GREGORY (*Secretary*), *appointed to consider and report upon the Influence exercised by Universities and Examining Bodies on Secondary School Curricula; also of the Schools on University Requirements.* (*Drawn up by the Chairman.*)

DURING the past few months the regulation of examinations has occupied the attention of a number of public bodies. It is an open secret that the Consultative Committee have had the subject of a school-leaving examination under consideration, as they have consulted both university authorities and teachers on the question; and that there is a trend of opinion in such a direction is shown, for example, by the action recently taken by the University of London in the matter of school examinations.

As a preliminary step a circular has been issued to the members of the Head Masters' Conference and other heads of schools, and to a number of university tutors, &c.; but as yet only a limited area has been covered, and it will probably be desirable to extend the inquiry in order to ascertain the opinion of teachers in general as well as of other competent persons.

In inviting opinions the following statement was made:—

For the purposes of this inquiry it is desired to obtain opinions from those whose work is affected in one way or another, or who have special opportunities of judging, with the object of eventually placing on record a clear statement of any objections that may be felt to attach to existing practices; and more especially to suggest alterations or remedies which if introduced would favourably influence the work both of schools and universities.

The subjects to which attention may be particularly directed are:—

1. The effect of examinations generally on school curricula. Do they, on the whole, tend to direct the teaching along reasonable lines; or do they interfere with the liberty of action of schools, and check the development of individuality and the power of independent thought?

2. The effect of specific examinations, both as affecting general training and as encouraging undue specialisation, either on the humanistic or the scientific side.

3. The need of unifying examinations with the object in view, among others, that certain examinations may serve a common purpose, *e.g.*, as qualifying examinations for entrance upon a course of professional study.

4. The need of preventing examinations from becoming stereotyped and behind the times, and thus discouraging the development of new or improved methods. How far does an interchange of opinion between the teaching profession and examining bodies already take place, and to what extent might it be extended?

5. The possibility of arranging outside examinations so as to test what

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has really been taught in the School, leaving the Teachers a freer hand than in the past, and arranging for their co-operation on the Examining Board, in the setting of the questions and in considering the answers.

6. The possibility of arranging so that examinations conducted on the basis of papers set so as to suit individual schools, with the answers marked in the first instance by the Teachers, subsequently criticised and standardised by outside authority, shall serve, when passed above a certain standard in a given range of subjects, as equivalent to the Entrance Examination for a University or for a Profession.

7. The extent to which certain subjects are to be regarded as necessary and others as optional. In particular, how far do University entrance examinations tend to promote a good all-round education?

8. The suitability of the training at present given in Schools as preparation for higher studies, (*a*) at the Universities and (*b*) in Technical Schools.

9. The suitability of the training given in Universities and elsewhere as a preparation for the teaching profession.

The following passages taken from the various replies (fifty-six) illustrate the general character of the answers given. Provisionally names are not attached to the answers, but only numbers. S indicates that the opinion comes from a school; U, that it comes from a university. Thirty-five opinions are from schools, twenty-one from universities.

1. The effect of examinations generally on school curricula. Do they, on the whole, tend to direct the teaching along reasonable lines; or do they interfere with the liberty of action of schools, and check the development of individuality and the power of independent thought?

While pointing out the many evils which attend examinations, the majority take the view that in some form they are necessary. It is generally recognised that there has been a marked tendency to develop and improve examinations of late years.

S 26. Examination has its place in education; and over and above this must be applied and endured as a test of relative merit and ability. Educationally its value depends on just co-ordination with the teaching given; and the more strict and definite the limits of a subject are, the more possible it is to secure such wholesome co-ordination from an external examiner. At the present time external examinations are carried to such wasteful and mischievous excess that they are doing more harm than good to the advance of education, and unfortunately tell most upon the best boys.

Every professional body appears to hold that it is forwarding education, or perhaps rather satisfying self-respect and rising to its position, by instituting schemes of examination and insisting on those particular tests as alone valid. Every British university frames its own scheme of subjects and books, to the exclusion of all others. Colleges, commissioners, boards, and committees follow the same course in respect of scholarship or admission tests. The schemes are arbitrary, conflicting, and needlessly inelastic, and together make havoc of all unity in school curricula. No one familiar with the whole field can place much faith in the opposed and contradictory conclusions enforced by different authorities. For instance, what a hotch-potch results from the place given to Paley, Jevons, Greek Testament, and trigonometry at Cambridge

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to mechanics and science at London; to history and English at Victoria University! Or, again, a boy is preparing for the Army: if he takes the Woolwich or Sandhurst route, Greek is virtually (except under heavy forfeit) disallowed; if finally he prefers Oxford, it is enforced. Even if he passes Responsions twelve or fifteen months before going into residence the college insists upon his keeping up Greek for matriculation purposes and subordinating or neglecting modern languages and mathematics until residence begins. These are but illustrations of a complicated mass of divergences. The total result of such pedantic and inelastic compulsions is disastrous, and is needlessly intensified by the usage of 'school books' in language examinations. The preliminary examinations for graduation (Smalls, Little Go, &c.) have been flung upon the schools, unity of curriculum has been made impossible, and the final year of school preparation is broken up by distracting and discordant examination calls.

Consider first the abler boys, candidates for scholarships or exhibitions. Successive scholarship competitions, 'Responsions,' 'Preliminary,' or 'Additional' examinations at Oxford or Cambridge, college entrance and matriculation tests, added to the indispensable school examinations on work done and for the adjudication of school awards, break up the year with harassing (and expensive) absences, and not much less than a quarter of a boy's whole time is *wasted* in examinations; while the preparation of set books on subjects encroaches seriously upon the remainder left available.

For less able boys the latter form of encroachment becomes much more serious. In practice for one, two, or (in extreme cases) three terms of the final school year boys must be withdrawn from parts or the whole of the school curriculum, forfeiting the stimulus, the emulation, and the interest that attaches to collective learning, and must be set in ones or twos to prepare the particular subjects or authors imposed by the authority to whose regulations he must conform each detail. To make matters worse, the examinations are timed quite irrespectively of school terms, and as a net result produce more idleness, more bad and broken and undirected work, than any other single cause to which I could point.

As to the effect of examinations upon study and teaching, external and impersonal examinations certainly tend to narrow, not to widen, the range; and the higher the stage reached, the more this becomes true. In the field of humanistic studies time and interest expended upon literary contest or side issues (*e.g.*, historical, archæological, artistic, mythological, philosophical, &c.) will pretty certainly be thrown away, and from *the examination point of view* what pays is close adherence to the standard commentary or text-book on the subject. On the whole this sets, and probably rightly, the limits beyond which the impersonal examiner hardly feels it proper to travel in examining a mixed field of candidates. Of some branches of science this is less true. But here, too, examination is apt to be restrictive and sterilising unless intimately co-ordinated with the teacher's work. In biology, for instance, or botany, two hours a week given to some representative corner of the subject is incomparably more educative than general outlines; but if gauged by impersonal examination tests might seem to yield an absolute zero of result.

But it seems waste of time to enlarge upon these obvious and admitted evils. Is any remedy or alleviation possible?

§ 30. General examinations in all subjects are wholly pernicious in

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their effects, not only in checking individuality and progress among teachers, but in tending to substitute facility of reproduction for originality of thought among the taught. It is a bitter disappointment to a young fellow to find at twenty-two that the work required to get on in the world is of a different nature from that which has hitherto brought him success in examinations.

It may happen that a boy has to get up the same subjects over and over again, to pass some examination in which he has been ploughed in some other subject. For instance, I have known a boy's whole education at a standstill for a year while he is getting up some one subject for the London Matriculation; and I have known boys go in four or five times for the L.C.C. Intermediate Scholarships, getting up the same 'elementary experimental science' year after year, their scientific education meanwhile being at a standstill.

S 35. The substitution of unseens for prepared books in the Civil Service examinations has an utterly cramping effect, as it leads to study of cram books of unseens instead of authors. Ordinary examination reports are useless, especially those issued by the Oxford and Cambridge Boards on inspectional papers.

S 25. Thinks that the examination of schools in classical and English subjects, which is mainly done by the universities, is done very badly. Points out faults and suggests reforms, thus:

1. Wrong men chosen for examiners—persons who have no experience in teaching in schools or persons who have failed in it.

2. Theory of examination misunderstood. Its real functions are—

(*a*) to stimulate boys;
(*b*) to inform outsiders and governors of condition of school;
(*c*) to improve the teaching.

The first is partially attained, the second very inadequately performed, the third (by far the most important) practically neglected. The teachers have no confidence in the competence of the examiners to advise or criticise.

3. Method wrong.

(*a*) Examination wholly or mainly on paper, and does not touch some of the most important parts of the master's work, *e.g.*, training of character.

(*b*) Papers badly set—

(*α*) far too long for boys to have time to think;
(*β*) test memory rather than brains;
(*γ*) questions often loosely and obscurely worded.

(*c*) Papers badly looked over owing to laziness of examiner and desire of schools for over-hasty results.

(*d*) The reports are practically useless. They do not deal at all with the training of character. Owing to the constant change of examiners they cannot detect forgers or deterioration. The examiner usually takes one or two forms, instead of one subject from top to bottom of a school, and so cannot detect the weak points. He never comes into real contact with the actual teachers. He does not know how many seeming failures may be due to causes beyond the teacher's control.

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Result is to (1) confine teacher to old ruts and discourage all attempts at improvement.

(2) Cause the teacher to devote disproportionate amount of time to written work.

(3) Foster 'cram.' The teacher considers, not what is best for the boys, but what the examiner will ask.

Reforms suggested: (1) Examiners should be drawn only from experienced and enlightened schoolmasters.

(2) Examiner should report, not merely on attainments of boys, but on curriculum, books, and school arrangements generally. Bad work is as often due to bad arrangements as to bad teaching.

Especially (3) examiner should spend several days at the school, listening to teaching and, above all, coming into close contact with teachers, so that he may know their aims and difficulties, and may give advice and encouragement rather than criticism.

(4) In the setting of papers the teacher should have a voice and a right of veto on such as he may deem unsuitable.

(5) Examiners should remain in office for several years, so as to observe progress and become intimate with the teachers.

Such reforms would, I believe, do much to free the teacher's hands. He would be encouraged to try new methods, and would be able to give practical effect to what is at present too often a mere theory, that a schoolmaster's real work should be directed, not to immediate and often superficial results, but to building up the character and training the intellect for life.

S 33. The effect on school curricula *nil* because it does not seem to be the business of examiners to criticise the curriculum or the time-table.

S 11. Examinations should conform to the teaching.

S 32. At present examination rules education. The learner is spoon-fed, and everything is made easy for him in order to get marks.

S 10. Examining bodies now more ready to take advice than they were.

S 19. In general the existence of and regard for outside examinations is useful to the schools as promoting a breadth and balance of the curricula. But the severity of examining bodies, &c., complicates and embarrasses school organisation.

S 9. On the whole, examinations, such as those of the Joint Board, are arranged on reasonable lines as far as curricula go. Perhaps required as a stimulus to the British boy. Regrets the tendency to conduct all examinations in writing, thus making *exact* but not ready men.

S 22. On the whole the examinations set by the Universities do tend to direct the teaching along reasonable lines. A notable exception is afforded in the fact that they do not test a practical knowledge of modern languages. Again, the retention of Greek as a necessary subject in the entrance examinations to Oxford and Cambridge is an anachronism. I am entirely in favour of the Bishop of Hereford's proposal.

S 18. Approves of the Higher Certificate examination, and would rather see Matriculation examinations on the same lines. The Victoria and London examinations are presumably for boys of sixteen; really they are for boys of seventeen or eighteen. Matriculation examinations should be general, not specialised, but with groups of subjects; nor should undue prominence be given to special subjects. The Oxford and Cambridge Locals Preliminary is useless.

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S 5. The Certificate examinations of Oxford and Cambridge tend to direct the teaching of most subjects along reasonable lines and interfere little with the liberty of action of schools. Army examinations with their cast-iron system of marking deserve the criticism they have lately received.

S 2. Examinations such as those of the Joint Board and the Locals on the whole seem to direct the teaching along reasonable lines; nevertheless they tend to check independence of action and of thought (*a*) in setting special books on periods, (*b*) in the mode of examining in modern languages. Some oral test is needed.

S 4. Everything depends on the character of the examiner.

S 13. Curricula should not be controlled by examinations but directly, and the examinations (more limited than at present and at early ages) arranged to fit the curricula.

S 15. Some interference is probably inevitable. On the whole it has diminished in evil effect very much within my recollection, chiefly because better papers (on the average) are now set. The worst effects are not, I think, direct, but are transmitted through the text-books. A bad examination always produces a crop of these in a few years, and many of them are indescribably stupid and disheartening. An Index Expurgatorius of such books might be of use to those engaged in reforming examinations. The object should be to make the examination of such a character that these books would not enable a candidate to 'score.'

S 34. Thinks that only the highest forms of a school should be subject to outside tests.

S 12. Examinations have of late years become much more elastic. Those who frame the various programmes show a desire to encourage a liberal school curriculum.

S 1. Ever since the first examinations for the I.C.S. came into full play the whole question has weighed on me like a nightmare. I believe that examinations as they are—with some rare exceptions—are giving a totally wrong trend to education. They are subsidising the receptive and discouraging the training of the instructive powers of the mind; they are encouraging a sort of cut-and-dried mode of teaching and learning which would have driven Arnold wild; indeed, under such auspices an Arnold could not arise, and (especially the Army examinations) they are imbuing most of their victims with a lively detestation of study. I believe that the dislike to the study of their profession, so marked in Army officers, is the natural fruit of their cramming to get into Sandhurst. Education cannot exist on an Army side, and cramming disgusts its victims. The true remedy seems to me to be to reform and not to abolish examinations. What should be encouraged by them is not crammed knowledge but mastery of a subject and intelligence.

The particular subjects of education appear to me to be of very secondary importance so long as the cultivation of the constructive and original rather than of the receptive faculties of the mind is the object aimed at.

S 3. Existing examinations have a most evil effect on school curricula and liberty of action in the larger schools, which are run by men who will rejoice in rather than abuse such liberty. Here we are blessed with an absolutely free hand, and teach how and what we like as far as science is concerned; the result is a large body of boys who are honestly keen on working at science (up to their lights, which are dim) in

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a school where intellectual effort tends to be rather despised. When necessary these boys pass examinations all right afterwards, such as Trinity Scholarship examinations and triposes. We never have to 'produce results,' so give all our time to educating the boys.

U 6. Effect on the whole good—a great help to the head master in resisting pressure put upon him by parents and amateurs.

U 7. While recognising the evils of the system is forced to recognise its very great merits as a most useful instrument in proper hands.

U 11. The Oxford and Cambridge Board examinations have had a beneficial effect upon school curricula: they have (*a*) made teaching and learning more methodical, (*b*) widened the scope of school studies, (*c*) brought important instruments on education into general use.

U 13. However reasonable the schedule of an examination may be, the preparation of candidates for it, in my opinion, checks development of individuality in both teacher and pupil. If a teacher has a special interest in some part of the work, and by his interest awakens that of his pupils, he is necessarily pulled up by the feeling that his students have to be prepared for the examination and the points in which both teacher and pupils are interested have to be left.

Far too much energy is wasted in England in setting and looking over examination papers.

U 18. The tendency has been steadily for improvement—they do now on the whole offer a reasonable scheme of work. Boy nature being what it is, a great step is taken when a motive has been suggested for individual and unassisted effort. This motive has been supplied by examinations. It is not, however, a good thing for schools—when it can be avoided—to depend for support on the results of a particular examination. The effect is almost inevitably that teaching is narrowed and everything neglected which does not 'pay.' Where this arrangement is rendered necessary by circumstances it is most important that such examinations should be as wide, liberal, and varied as possible, and that every effort should be made to secure that the papers set should offer as little scope for 'cramming' as possible; and as, after all, the skill of the crammer is pretty sure to be a match for the examiner, such examinations should be, at any rate in part, *viva voce*, by which method such teaching is most readily detected. With this precaution I do not think an examination need 'check the development of individuality and the power of independent thought.'

U 19. If sufficiently broad and conducted by examiners of experience need not check individuality, &c. On the whole advantageous as stimulating effort; often a means of enabling the schoolmaster to judge whether his work is in line with that of other schools.

2. The effect of specific examinations, both as affecting general training and as encouraging undue specialisation, either on the humanistic or the scientific side.

Very little difference of opinion exists on this subject.

S 26. *Scholarship examinations* do certainly bring irresistible pressure to bear in favour of early and injudicious specialisation. So far as scholarships go the classical boy does well to discard all mathematics, modern languages, or science; the mathematician to renounce classics and modern languages, &c. For this I see no remedy short of a complete change of system, which is impracticable. Examiners approach their subject as

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specialists and judge accordingly, while they give little or no weight to a sound background of training in other subjects. I have no faith in first forcing specialisation by scholarship tests and then attempting to redress the balance by enforcing supplemental subjects through subsequent requirements. This will but aggravate the evil and produce successive bouts of cram—'Pull baker! pull devil!'—according to the emergency. It is better to leave them alone, recognising certain concomitants of mischief as inevitable. The synchronising of examinations is a great abatement of previous evils.

S 5. Entrance scholarship examinations at Oxford and Cambridge, especially those given for mathematics and science, mischievously affect 'general training' and encourage undue specialisation. The coil of their system propagates itself downwards through the public schools into the preparatory schools.

S 17. The professional examinations are bad, inasmuch as they do not take the school training into account, but merely knowledge of facts.

S 19. University scholarship examinations tend to over-specialisation; hardly any encouragement is given now to the double man at either Cambridge or Oxford. The high range of knowledge exacted for mathematical scholarships and the inordinate amount of experience in working problems which a candidate must now possess, compels a specialisation in mathematics which is certainly very detrimental to general development of the mind, and tends to atrophy of the imaginative faculties, which require literary nourishment. The want of this at the ages of sixteen to nineteen can never afterwards be made up. Over-specialisation in classics is less detrimental, as the study tends to widen the range of ideas rather than narrow them.

S 18. London County Council Exhibition Scholarship examinations force specialisation at an absurdly early age. This is true of other County Council examinations.

S 4. It is the offering of money rewards for learning certain things which is so pernicious.

S 14. Specialising should be discouraged in every way. For school examinations a school might be invited to submit its curriculum and method. If this was pronounced sufficient for its type, it might be inspected on it and judged by it. The question is, what are the results? *Viva voce* should always form a part, a V.V. on the ground covered.

Too little time is allotted to the literary work in organised science schools; too little for the mere training of mind. Mere school science, unbalanced by thorough linguistic training—training in thought, not mere grammar detail—is one-sided. It produces in second-rate minds too exclusive an attention to mere symbols. Such minds find all *nuances* of language extraordinarily difficult to master.

If a boy is transferred from the general side, rather late, to the organised science side, he 'licks the heads' of the ordinary boys in a little while in their own subjects.

S 3. There is much to be said for specialisation by a boy at the end of his school course. It is a fashion to decry all specialisation as 'undue'; but a boy after he is seventeen gets a vast deal of good out of one side of his work thoroughly dealt with which he would not get if he carried on the one or two hours a week at everything, which is good up to then. Of course I dislike complete dropping of all other subjects while he crams for a school; but I think he would do better, if he is in the VIth form, if

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he spent, say, three-quarters of his time really getting to know his one branch thoroughly.

S 8. *Specific Examinations.*—(*a*) The higher certificate (Oxford and Cambridge Board) encourages undue specialisation in a less degree than the University Scholarship examinations. For the latter a boy of average ability must specialise in one subject—classics, mathematics, or science—at the age of sixteen or seventeen at the latest; and the higher certificate examination follows the same lines, allowing a boy to compete in his special subject if he has passed in the larger range of subjects; (*b*) but the worst offenders seem to be the Science Scholarships examinations, which expect candidates to have covered much the same ground as the Final Honours examination for a degree. Thus a boy has to acquire some knowledge—which at eighteen cannot be thorough—of a large number of subjects, instead of ensuring sound knowledge of a limited range. The student is thereby also inclined to be stale before the end of his time at the university; (*c*) Army examinations require an all-round education; but for the average candidate too much is required for thoroughness.

S 13. The great defect of examinations affecting schools is the undue multiplication of subjects and the consequent want of thoroughness all round. The new regulations suggested by the Committee on Military Education, as also those for London Matriculation, seem to me a great improvement in this respect.

Much will be gained when it is clearly recognised that school work must be general; that curricula of some three or four types are sufficient; that specialisation is the work of the universities or technical scholarships. This does not mean that a boy of high ability should not specialise at all at school; he may rightly do so in broad subjects—classics, modern languages, mathematics, or science—but schools should not be asked to give specialised or technical education of a narrow type.

U 19. In school examinations examiners should not ask questions of a highly special nature; it is difficult to avoid doing so when, as sometimes happens, schools send in highly specialised syllabuses.

U 7. The bases of knowledge are now being tampered with, whether rightly or wrongly; and so far as the newer humanistic studies are concerned it would, in my opinion, be deplorable were students allowed to specialise, say, in modern languages and literatures or history without being subjected to some qualifying examination in Latin or Greek. There should be some common examinations guaranteeing general education, one examination with special reference to candidates preparing for humanistic study and another for those preparing for scientific study. Scientists will no doubt be divided on the question of making Latin compulsory: they should be united, however, in demanding from all candidates an adequate knowledge of English and some recognition of good style in composition.

U 21. Does not consider the influence of University Entrance Scholarships to be good. When examiners have no personal knowledge of the candidates or of their previous careers, the difficulty of comparing their abilities and their power of benefiting by a university training is very great, and the examination is too likely to become a mere test of acquirements. Such a result must prejudicially affect the previous education of the candidates, particularly in tending to narrow their training to an early preparation for a definite and specialised examination. As a

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general scheme of reform it would be well to devote more of the college funds available for these purposes to scholarships for undergraduates who have already begun residence, and especially to post-graduate fellowships and studentships for research. An increase of the endowments of secondary schools to enable them to award more leaving scholarships tenable at a university would be an efficient substitute for the present system of open entrance scholarships at the colleges of Oxford and Cambridge. Any such change would, however, require the co-ordination of the whole secondary education of the country.

In arranging an open entrance scholarship examination in such a subject as natural science the chief difficulty is to provide for two distinct classes of candidates: (1) boys, often under eighteen years of age, just leaving school; and (2) those, usually rather older, who have spent some time at a university or technical college, specialising on the work in which they are to be examined. In order to help the schoolmaster to give a thorough training in the groundwork and main principles of science, it is advisable that the papers set in the scholarship examinations should largely deal with these parts of the subjects; while, to properly test the merits of older candidates who have spent some time at the work, more advanced questions are requisite. A satisfactory judgment cannot be formed on the results of the examination alone, and under present circumstances it is necessary to make allowance for what is known or can be ascertained of the antecedents of the candidates.

U 10. University entrance scholarships, while successful in so far as that they do pick out the able students in each subject, are at present doing great harm by encouraging early and excessive specialisation to the detriment of the student's subsequent career. Thus, for their knowledge of chemistry and physics, scholarships are awarded to boys of eighteen who have in far too many cases a very inadequate grounding in mathematics, are ignorant of history and of modern languages, possess a smattering of Latin, and cram up subsequently enough Greek to carry them through the 'Little Go' or its equivalent. Equally bad is the case of the winner of a classical scholarship who, beyond his knowledge of Greek and Latin, has a slender acquaintance with Euclid, algebra, arithmetic, and French.

Worse still is the condition of the mathematician who as regards general education is more poorly equipped than the rest.

The best of these men often repair their deficiencies later by their own efforts; the second best remain losers.

This evil might be met by insisting that all scholarship candidates should pass a suitable matriculation examination before they were allowed to compete for scholarships in special subjects. Most matriculation examinations would, however, require to be considerably improved and widened in their scope before they could be used for this purpose.

U 11. Whilst the Oxford and Cambridge examination of schools seems to me to have done unmixed good, I hold that open examinations for college scholarships have done, are doing, and will continue to do much harm by encouraging schoolboys to specialise early in some one branch, whether of literature or of science. The schoolmaster is compelled (*a*) by the natural desire to advertise his school, (*b*) by the absolute necessity of meeting the reasonable wishes of parents, to prepare his boys for open college scholarships, obtainable only by candidates under nineteen years

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of age, and therefore to allow them to specialise as soon as they show any special aptitude. This seems to me a misfortune. To prevent it I would provide that colleges shall not award scholarships before entrance to candidates who are not in need of pecuniary assistance to enable them to begin residence at the university. I think that if every candidate had to make a simple declaration of such need the knowledge that the competition was a limited one would destroy the unwholesome interest which it now excites, and that the schoolmasters would no longer have any inducement to prefer premature successes to sound education.

It is to be noted that legislation in respect of open scholarships would be useless unless it applied equally to all the colleges both at Oxford and at Cambridge. The Cambridge colleges opened scholarships to schoolboys, not because they thought the practice a good one, but because, in face of the Oxford competitions, they found themselves obliged to follow suit; and I believe that in this matter public opinion at Cambridge has never wavered.

The legislation which I recommend would make little pecuniary difference to the successful candidates. In general the candidate who now as a schoolboy wins a scholarship at Trinity nine months before he goes into residence, and begins to draw the emolument when he goes into residence, would, under my regulation, obtain his scholarship and begin to draw the proceeds as an undergraduate six months after he began his residence; and if in need, though not otherwise, he would have a temporary emolument to help him during the six months.

U 11. Open examinations for college scholarships have done, are doing, and will continue to do much harm by encouraging schoolboys to specialise early in some one branch, whether of literature or of science. Amongst grown men specialisation is a necessity of the age, and consequently colleges, in choosing their scholars, must needs take account of special aptitudes. Now college scholarships awarded on this principle to undergraduates who have already begun residence do not materially affect the teaching in schools; but college scholarships awarded for special proficiency to schoolboys affect school teaching very seriously, inasmuch as the schoolmaster, however little he may approve early specialisation, cannot afford to disregard these important prizes.

U 17. Set books should be abolished in the Cambridge previous examination. Some elementary scientific subject should be introduced and some knowledge of a modern language should be insisted on.

U 9. My own experience makes me strongly opposed to early specialisation. In scholarship examinations performance in a special subject should be estimated only in connection with proficiency in ordinary school work. It is very easy to devise a scale of marking according to which general knowledge and evidences of culture are appraised in connection with skill in a special subject; *e.g.*, Jones: chemistry 50, general culture 25 = 75; Brown: chemistry 60, general culture 10 = 70.

U 1. I should be sorry if specialisation ceased in schools; but much more ought to be made of a candidate's special subject as an instrument of general training. It ought to be used as a means of interesting the candidate in kindred subjects—a sort of avenue to knowledge in general.

3. The need of unifying examinations with the object in view, among others, that certain examinations may serve a common purpose, *e.g.* as qualifying examinations for entrance upon a course of professional study.

On this question opinion is practically unanimous.

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S 26. For *Preliminary and Entrance tests* the crying need is unity and simplification. Here reform is not difficult *if* the co-operation of the different bodies concerned can be secured. There lies the problem. I believe a test examination might be devised fitted to supersede or replace the multifarious preliminary examinations (academic or professional) that now exist. It should be treated as a school-testing examination. Its aim and methods should be strictly pass, not competitive, certifying the attainment of such and such general standard of knowledge in such and such subjects. The range of subjects should be as wide as that of school curricula; all forms of option or grouping should be allowed. There should be no attempt to award honours or places, but merely to guarantee first, second, or third class proficiency in the subject offered. There need be no inquiry into the age of candidates unless a junior standard for candidates under sixteen were organised, and for this there is much to be said. [In this case two classes would be ample for either higher or lower test.] Each institution or profession would formulate its own conditions of age, standard, selection and grouping of subjects, and so forth. This would give freedom, latitude, and recognition to all forms of curricula and set up something like a recognised and common standard intelligible to all conversant with education. It would be imperative to exclude all set books, or it would at once fetter curricula and encourage cram. The use of dictionaries should be allowed, though the class award might to some extent depend upon this. Their disallowance is absurd, and ignores all the ordinary and necessary conditions of daily training in languages, especially classical. The substitution of set books for use of dictionaries is mere hiding the head in the sand, and brings with it a whole train of mischiefs and dangers. Times of examination should be harmonised with the needs and usages of secondary schools, and the examination be held as far as possible at all schools presenting candidates.

The cardinal difficulty is to secure the adhesion and co-operation of universities, colleges, and other educational boards. Conference might render this possible, and the Board of Education might supply a nucleus round which such bodies might unite without surrender of corporate dignity or independence.

Apart from this examination, open at any time during the school course, schools should, so far as possible, have examinations individual to themselves moulded upon the lines of their own teaching; expense would be diminished, and co-ordination of examination with teaching be secured by the co-operation suggested in §§ 5, 6. The examiner's report would be that of a general inspector, for guidance of the governing body and responsible directors of the school; while the general test examination would furnish the public certificates of general efficiency now supplied by senior and junior local examinations and the like.

S 16. This is the most urgent question in connection with secondary education at the present time. There ought to be a single qualifying examination for boys leaving school between sixteen and seventeen, and another for boys leaving between eighteen and nineteen for universities. Examinations such as the University Locals preliminary unnecessary from any point of view.

S 6. This can and should be done.

S 25. Recommends one examination held jointly by all the bodies concerned.

§ 33. The effect of unifying examinations would be most advantageous.

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S 11. One common preliminary examination for all professions required. A leaving examination would be a great boon.

S 10. The need for this is very great.

S 19. A common gateway would be a great boon. Much derangement of school work would be obviated if the examination could be taken at the schools at the end of the school term.

S 9. The variety of qualifying examinations is a crying evil.

S 22. I fully recognise this need.

S 18. Approves of a leaving examination at sixteen in general subjects. A boy should not be disqualified for failure in one subject.

S 7. Unification not so necessary as elasticity. The late isolated regulations for the London Matriculation were an intolerable strain on a VIth form when the majority were working for the Joint Board examination.

S 17. The need is paramount, especially for the smaller schools.

S 2. Great need of unifying. The unification should be as comprehensive as possible.

S 4. Much might be done advantageously to diminish the number of examinations if all universities recognised one another.

S 14. All entrance, professional, and university examinations should be unified, the standard *settled*, the *bases* settled, no fixed books, and *every* examination paper should contain a large number of questions with a choice to be restricted to a certain proposition. On such unified papers the certificates might be granted.

The harm done by so many varying examinations is very great. There is great waste of time and power caused by a variety of set subjects and authors in languages. We want two certificates based on as wide a freedom of teaching as possible—one for boys sixteen to seventeen, one for boys eighteen to nineteen.

S 8. This is all-important. A resolution to this effect was carried at a recent Conference of Secondary Schools in Kent, and it was sent to the Board of Education and members of Parliament.

S 30. My remedy for the examination evil depends upon the following principle, that examination is to accompany and to be subordinate to inspection. For instance, the examiner is also an inspector who visits the school, studies the methods of work, notebooks, and exercises, and sets papers in consultation with the teaching staff: these are looked over as may be directed by the examiner, his assistants, and the staff. Certificates are given according to the standard attained.

Groups of schools in the same locality might be examined together, conferences of teachers being held, under the inspector, for the setting of papers.

Every boy under sixteen must be examined down to the most hopeless of duffers. Set books would of course be absolutely abolished.

Professional bodies would state what standard they would require for entrance into any profession, and would undertake to hold no private examinations.

No boys under a certain age would be allowed to be presented for examination, and it would be easy to make arrangements to prevent the repeated entering of the same boys.

This examination would entirely replace all the examinations in general subjects; examinations of a higher standard would be in special subjects, and would be limited to older boys.

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S 13. All the special preliminary examinations of professional bodies should be abolished. Broadly, two types of leaving certificates are wanted—(1) for boys of eighteen to nineteen, (2) for boys sixteen to seventeen.

U 2. Very advisable and quite possible.

U 7. University entrance examinations should be planned on the same lines at one and all the universities.

U 8. The proposal sounds well, but all will depend on who does it.

U 11. I have long wished for some sort of unification; that there should be in kindred examinations (*a*) a general agreement in regard to the schedules of the several sections; (*b*) a complete agreement in regard to movable subjects, so that, for example, set books in French and German should be the same for all kindred examinations for the year.

U 28. Surely something might be done towards having a standard leaving examination, properly graduated, in all schools. The number of examinations, often with many different subjects and with fixed books set, are a great nuisance and interfere with teaching sadly.

U 17. Strongly in favour of one single examination such as exists in Germany or such as the Scotch leaving certificate, which would prove a qualifying examination for entrance to all professions, including, if possible, the Army and the Navy.

4. The need of preventing examinations from becoming stereotyped and behind the times, and thus discouraging the development of new or improved methods. How far does an interchange of opinion between the teaching profession and examining bodies already take place, and to what extent might it be extended?

It is generally felt that it is desirable that examiners should confer with teachers in some organised way.

S 16. No real danger of this.

S 33. The need is great. The personal qualifications of those engaged in examining are too little regarded. Little or no interchange of opinion between teachers and examiners.

S 11. Exchange of opinion would be valuable if schools were examined by those who are or have been teaching in schools, not by young graduates who have never taught.

S 10. The I.A.H.M. has had several conferences with examining bodies with good results.

S 19. Certainly the two parties should be more in touch. There is no organised or formal inter-communication.

S 9. There is an improvement in these matters quite recently. But schools suffer from the fact that those who organise papers, and set them and examine them, are too often totally ignorant of the creature examined—the average schoolboy—and proceed on lines dictated by their experience of young men or clever boys. The Oxford Local Delegates committed a flagrant instance of this last year, but during the last six months schoolmasters have actually been consulted—for the first time during ten years. Hitherto their method had been to listen to criticism after, but not to consult before.

S 2. Interchange of opinion very valuable. Authorities are probably afraid to do anything which would tend to diminish the popularity of their examination or to raise the standard unduly; and the standard is in some respects too low.

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Possibly a *review* of existing systems of examination, say once in five years, by a conference of representatives of examining bodies and teachers would prevent the evils suggested and encourage the development of improved methods.

S 4. One must be dependent on the character of the examiner. He should certainly be adequately criticised, and both the teacher and the examiner might profit much by an interchange of views.

S 12. Have found the secretary of the Cambridge Local Syndicate ever ready to listen, to discuss, and even adopt suggestions.

S 14. I think conferences between teachers and examiners would be most useful. We want frequent conference.

S 8. The Army examination in chemistry has been stereotyped for twenty years. The questions in practical work are confined to analysis of simple salts. This year there is a sign of change, due, perhaps, to representations made by the Conference of Public School Science Masters.

Interchange of opinion is much to be desired.

S 15. Teachers are, I think, rather shy of making complaints or suggestions lest their motives should be misconstrued. Some examining bodies are haughty.

U 19. An interchange of opinion is always desirable. Every attempt is made by some examining bodies to keep the examinations up to date.

U 2. Distinctly necessary; the arrangements for interchange of opinion ought to be extended.

U 7. There should be annual conferences between the teaching profession and examining bodies, and the papers set at the various examinations should be subjected to frank criticism.

U 8. Sees the need all too clearly. It might often be very useful to hear what the *real teachers* have to say.

U 12. Examinations tend to become stereotyped, because examining bodies frequently find themselves unable to pay on a sufficiently large scale to attract really competent examiners.

U 18. It is a truism to say that examinations should not be 'stereotyped' or 'behind the times.' The remedy is to employ competent examiners, directed by a competent board, open to all representations from practical teachers.

The difficulty of organising inter-communication between boards and the teaching profession is, I imagine, that the latter is not organised. There is no properly qualified spokesman of the teaching profession; and the difficulty of aiming at definite results of big value has been rather strongly exemplified by the history of the Head Masters' Conference.

U 17. I think schedules and syllabuses of examinations might be changed more frequently than they are with advantage. In most University Scientific examinations the examiner and the teaching staff are freely in communication with each other, and I should like to see this exchange of opinion extended to school examinations, and especially to entrance scholarship examinations.

U 1. More care should be taken in the selection of public examiners, and bad examiners should not be reappointed. This is a truism, but it is constantly ignored in practice.

U 14. It would be a great gain if examiners could have more criticism of their papers at the hands of schoolmasters. In the great majority of cases they have nothing to guide them as to the suitability of their papers but the way in which they have been answered. This will show if a paper

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has been too hard, too long, or, on the other hand, too easy, to fairly test the better candidates; but it does not show whether a paper has fairly covered the range of work done by the candidates.

U 3. I feel very strongly on this. We are likely to get the 'professional examiner,' as we have the professional witness; and he will be the more mischievous in that his influence will be the more universally diffused.

5. The possibility of arranging outside examinations so as to test what has really been taught in the School, leaving the teachers a freer hand than in the past and arranging for their co-operation on the Examining Board, in the setting of the questions, and in considering the answers.

There appears to be a strange disinclination to insist that the teacher should be trusted.

S 6. Would rejoice if this were carried out.

S 16. Unfortunate to weaken external examinations in either of the ways indicated in this or § 6; but 3 must be settled before this is dealt with.

S 11. Advocates system corresponding to that at the universities, where the internal and external examiner co-operate.

S 19. There appears no reason why a supreme Examining Board might not develop the scheme of the Oxford and Cambridge Conjoint Board for thus testing schools in such work as the schools might wish to submit. Teachers might furnish syllabus, text-books, note-books (pupils' or teachers'), and specimen internal examination papers to suggest and guide drafting of questions by external authority.

S 22. If the public examintions are on the right lines there would be no need for this plan, which would be attended with almost insuperable objections.

S 9. Something might be done.

S 5. We have nothing corresponding to the excellence of system prevalent in some Continental countries by which, for individual examinations, members of the teaching staff are associated with the external examiners.

S 17. Quite possible with care.

S 2. While I should be in favour of leaving the teachers as free a hand as possible in the achievement of their results, and would give them full right to criticise the examination papers set, with a view to improving the future character of the examination, I would allow *no hand* to the teacher of any subject in setting a paper in *that subject*. Consciously or unconsciously, his foreknowledge of the coming examination would influence his teaching, the standard of knowledge be lowered, and the examination become no real test.

S 4. Might be done with advantage; but it could not be done with an expectation that there would be no unfairness.

S 13. Seems impossible so long as the ideal is an examination uniform all over the country. It seems to me that this is, therefore, a wrong ideal, and that where possible a real local examining board should be formed by the local University representatives of local schools. In this case (*b*) the collaboration of schoolmasters might become possible and is desirable; the idea that this would lead to unfairness should be discountenanced.

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U 19. Does not favour this.

U 8. A clumsy attempt to do what was formerly done by getting a good honest examiner to go down to a school, making him (not a board) responsible, and letting him report unbowdlerised.

U 13. The real way to prevent the evil mentioned in 4 is to be found in some such method as is indicated in 5 and 6, in that the examination should be suited to the teaching, and that the teachers should thus have a freer hand.

U 10. It is very desirable for teachers to be represented on examining bodies and to have opportunities of seeing the work sent in by their pupils. Much conscientious labour on the part of examiners is at present almost thrown away for lack of suitable opportunities of discussing weak points with teachers and taught. The formal report helps but little in this.

6. The possibility of arranging so that examinations conducted on the basis of papers set so as to suit individual schools with the answers marked in the first instance by the Teachers, subsequently criticised and standardised by outside authority, shall serve, when passed above a certain standard in a given range of subjects, as equivalent to the Entrance Examination for a University or for a Profession.

S 6. Would rejoice if this were carried out.

S 33. Theoretically admirable, but hopeless in view of the number of bodies to be catered for and their different standards. Danger that standard would be lowered to the bottom level.

S 18. If it were not for the multiplicity of examinations schools would run in parallel groups, and it ought to be easy to standardise papers.

S 5. Such an arrangement both feasible and desirable.

U 19. The Cambridge Higher Certificate is accepted by a variety of bodies.

U 2. The suggestion should be carefully considered.

7. The extent to which certain subjects are to be regarded as necessary and others as optional. In particular, how far do University entrance examinations tend to promote a good all-round education?

There seems to be but one opinion with regard to the entrance examinations at Oxford and Cambridge.

S 11. There should not be a very wide choice of optional subjects.

U 15. Separate examinations at universities do harm, inasmuch as they tend to encourage undue specialisation. Suggests that separate examinations should be part of the university entrance examination, and that a general knowledge on the humanistic as well as on the scientific side should be demanded.

S 19. Does not think a number of options necessary or desirable.

S 18. Thinks that no examinations promote an all-round education except the Oxford and Cambridge Joint Board examinations.

S 6. Thoroughly agrees with the general principles advocated in the Bishop of Hereford's Glasgow paper, and in particular would wish to see Greek no longer a compulsory subject for entrance examinations.

S 17. Ought not the University entrance examination to be a test as to whether a student is fit to take a particular university course with advantage? General culture is most desirable, but you cannot force it;

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and we should not shut out a student desiring special knowledge and fit to advance on that special study because he has not got general culture.

S 2. Oxford and Cambridge entrance examinations exercise little influence on education as a whole. The London Matriculation has lent itself to cram.

S 4. A most depressing circumstance that the Oxford Local examinations make arithmetic optional; our absurd system of spelling compulsory. The London Matriculation unsatisfactory; ought to have a wider basis.

S 30. As to subjects necessary or optional. This is where the greatest mistakes have been made in the past: subjects have been propounded with the greatest minuteness. What is wanted is that the subjects should be grouped, and the selection of subjects within the groups left entirely to the head master; for instance, the following groups suggest themselves: Ancient Languages, Modern Languages, Science, Mathematics, English, Art. Within any one of these groups the students would select as much or as little as they liked. For instance, in Languages some would select three languages, others one; in English some would take Scripture, history, geography, history of language, &c., others only one of these subjects. Certificates would be given accordingly, and there would be no competition. The great point to be aimed at is to give absolute freedom of choice, and the standard reached by each person stated on his certificate.

S 21. The Universities handicap schools, inasmuch as the entrance examinations encourage premature specialisation and by failing to insist upon a respectable standard of general education.

S 20. The range of subjects in entrance examinations (Oxford and Cambridge and Army) is much too narrow. English and elementary mathematics should alone be regarded as necessary. Other subjects should be optional, and a good standard required.

S 8. Dublin seems to encourage an all-round education. I admit with regret that the conviction has grown on me that Oxford and Cambridge do not. The pass-man at these two universities ought to be required to know something of other subjects than classics, mathematics, and a little divinity. For Honours specialisation after eighteen may not be open to the same objection as at an earlier age or in the case of pass-candidates. By an 'all-round education' I should understand English (including history and geography), mathematics of a practical kind in the simpler branches. Classics: Latin at least, if not Greek; but I would give Greek the preference if it were feasible; a modern language with colloquial knowledge; and some general elementary science. The London Matriculation aims at this course, and would be a good test of school work if the papers were not apt to be tricky.

S 13. On many schools University entrance examinations produce no effect; so few boys go on. The particular difficulty in connection with them seems to be, they must not be too hard or the moderate candidate would be barred out altogether. Hence they may not be (and are not in fact) hard enough to draw out the better boys; *e.g.*, if a boy in the Vth form can pass the university entrance he may either (1) go to the university too early, or (2) feel that he has no stimulus when he is in the VIth.

This can probably only be met by relying, not on examinations at all, but on the school itself for stimulus.

U 5. Dwells on the neglect of modern languages in the Cambridge

entrance examinations. Only four of the colleges allow these as a subject of their entrance separate examinations. They are entirely excluded from the general examination for students proposing to take an ordinary degree.

U 2. The standard required in any university entrance examination is not high enough to affect any but the weakest candidates.

U 8. A good training in elementary mathematics is one of the greatest of boons. The endeavour to shirk this is a grave evil in modern education. It has done harm even in Cambridge. As to university entrance examinations Cambridge has not got one.

U 12. A paper or papers in natural science should be set in university entrance examinations.

U 21. As to those for scholarships other than university examinations, and their effect on schools, it is evident that an opinion on this subject must depend on the views held by the observer as to the best subjects of university study for the average man whose abilities are not up to the standard of scholarships. Leaving out of account the more or less professional subjects, such as law, medicine, and engineering, I personally think that the habits of observation and induction which may be acquired under favourable circumstances by the experimental study of some branch of natural science, and the power of weighing evidence, and the knowledge of the present social and political condition of the world given by the study of historical and economic subjects, are the best preparation for the life of the average man and most likely to make him useful to the State. As a possible future change I think there is much to be said for a course of university study which involves both these subjects, or some one branch of each, as an ideal training for those who have no intention of taking as their life's work the study of any branch of knowledge.

It is a matter of experience that a subject which has not formed the main part of his school course comes with greater freshness to the average English public-school boy, and is more likely to awaken a real and effective interest than branches of learning at which he has, often unwillingly, spent many hours a week for several years.

If we accept these contentions it follows that the general school course, besides providing a satisfactory means of mental training, should be especially adapted to serve as an introduction to historical and scientific studies, free opportunities being given for boys who show definite tastes or exceptional ability to diverge from the general course. Some such general scheme as the following might be suggested :—

As preliminary to both history and natural science : English language and literature, physiography.

As preliminary to historical subjects : classics, modern languages, and general history.

As preliminary to natural science : mathematics, natural history, elementary physics, and (perhaps) chemistry.

Such a course comprises practically the same subjects as those which are already usually taught, but very different relative importance would be assigned to them, and the method of treating them would undergo considerable modifications. Classics and mathematics would assume a less prominent position than they now occupy, except for those boys who showed special aptitude for either, and mathematics would be treated

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in the less formal and abstract way which has lately been freely advocated.

The university entrance or previous examinations would require readjustment to form a fitting conclusion to such a school course; and it is probable that this readjustment would be the most effective way of gradually bringing about some changes in school education. Whether it would be possible to carry the reforms indicated through the governing bodies of the universities it is difficult to say. I believe there is more chance of doing so now than there has been at any previous time.

U 10. University entrance examinations, such as the 'Previous' at Cambridge, are far too narrow in scope.

English subjects (including history and geography), mathematics, one ancient language, one modern language, and one natural science subject should be compulsory. Considerable freedom of choice in the matter of the modern language and of the science subject should be permitted; and while a fair average mark should be required for a pass the standard in any given subject ought not to be fixed too high. At present the narrow range of subjects required for entrance is unfavourable to the acquisition of a good all-round education.

U 18. The question as to optional subjects is not simple or easy. The three human faculties that education must at least deal with are speech, reason, and observation. The subjects which on an average will best deal with any one of these can hardly be reckoned optional. A correct use of languages seems to demand the study of some one language, at least, other than that which the student speaks instinctively.

For the second object I do not think anything has been found, or is likely to be found, better than elementary mathematics. How far it is possible to make some elementary study of physics a compulsory part of a university first examination I do not feel competent to form an opinion. I would only say that it seems a subject no less important than the other two, and that the now almost universal teaching of it in schools might be greatly improved and made more real if the universities could see their way to make it as compulsory as languages or mathematics.

U 16. I regard all examinations of a fixed character as objectionable unless necessary for testing professional knowledge or for selecting men from a number of candidates for posts in the Civil Service, &c. In the latter case they are still objectionable, but I fear unavoidable.

For universities and schools, however, fixed examinations are not necessary, and are as objectionable as religious tests. They stunt the minds of all those (the majority) who are not able to excel in the particular subjects selected; they have a narrowing effect on the teacher, and they stop progress in educational matters. The taught ought to be examined in the subjects which they have studied. Some of these subjects must be compulsory, such as reading, writing, arithmetic, &c.; but in the higher walks of education there should be no compulsion, but freedom as complete as possible in the choice of subjects, so that each mind should have a chance of developing its own qualities to the highest extent.

Curricula ought to be abolished whenever possible; so ought entrance examinations at the great natural seats of learning. These places ought to be free to all who are willing to study; and this willingness and capacity to study ought to be tested by examinations at stated periods in subjects or subject selected for study.

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U 1. A good all-round education seems to me very difficult to define; but whatever definition we adopt I doubt whether the university 'Previous' examination can be fairly said to promote anything of the kind.

8. The suitability of the training at present given in schools as preparation for higher studies, (*a*) at the Universities and (*b*) in Technical Schools.

U 4. Boys under nineteen gain scholarships at Cambridge for chemistry and physics without having a real grounding in mathematics, for history without possessing a working knowledge of French, to say nothing of German; and for Hebrew without first acquiring a real training in classics. Head masters ask and expect that scholarships should be given in these special subjects.

U 15. Lack of training of the mind generally noticeable in students coming to the university.

U 2. The candidates from many schools may not be accepted as efficiently trained in scientific theory and set to more advanced work.

U 8. It would be better if boys were not put on the strain to gain open scholarships. There is too much special preparation for these.

U 9. The results obtained in the technical schools are meagre owing to the want of preparation in the students at the time of entry.

U 20. I have observed two special defects which would appear to result from the training at present given in schools. One is the inability to write lucid and correct English. The other is the incapacity for independent work and thought. The second has, as far as my observation goes, increased perceptibly during the last fifteen or twenty years. The majority of undergraduates seem to have no idea of working on their own lines; they are dependent on their school tutor for the choice of a college and on their college tutor for the choice of a profession; they are even unable to read a book intelligently for themselves.

9. The suitability of the training given in universities and elsewhere as a preparation for the teaching profession.

S 3. Universities seem to me to tend too much to specialisation for their cleverer men to be the ideal training-ground for teachers; they rate ability by success in one subject, and a teacher should be cultured all round. It is, I think, in spite of their curricula that they supply good teachers.

S 10. 'In science, schools are too ready to consider that because a man has a science degree he can therefore *teach* science. I find a great difficulty in making the science teaching as thorough as that in other subjects. The number of science teachers has increased enormously during the last few years. The ordinary science master plans out a course of lectures, and goes through them on the dates he has previously arranged, so as to get through his *course* in a given time. He doesn't *rub it in*, and he doesn't revise enough. We want *trained science teachers*.'

S 12. My conviction is that (except for brilliant men who will have to teach brilliant boys) nothing could be much worse than the Degree examinations, as at present arranged, for men who are to become teachers.

S 8. The universities do not prepare men for the teaching profession.

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The best teachers have probably been produced from university men, but the university course does not develop the all-round man that a teacher should be. As a rule the Oxford or Cambridge graduate has no notion of such subjects as English grammar and language or elocution, seldom of modern languages, history, or geography, unless a specialist. He is either a mathematician or a classic, or perhaps a history specialist.

S 15. Very unsuitable when a sufficient standard is attained at the university. I am probably heretical on this point, but I have very little faith in 'Pädagogik.' The best teachers I have known knew or cared nothing about 'theory,' and certainly never thought about it when teaching; while theorists, both learned and ingenious, often fail completely in the practical part. I think a very free 'probationer' system would do good, but set no store by criticism lessons or lectures on method. Real education is being strangled in Germany at the present time by excess of training and system, which is more dangerous to the development of individuality and the power of independent thought than many bad examinations.

U 5. Refers to need of travelling studentships in modern languages for students who have passed the tripos and intend to become teachers.

U 2. If head masters could be induced to demand men with a sound teaching knowledge of their subjects it would be of great help to the universities in encouraging some of the students to do teaching rather than examining work.

The Conditions of Health essential to the Carrying on of the Work of Instruction in Schools.—Report of the Committee, consisting of Professor C. S. Sherrington (*Chairman*), Mr. E. White Wallis (*Secretary*), Mr. E. W. Brabrook, Dr. C. W. Kimmins, Professor L. C. Miall, *and* Miss Maitland.

APPENDIX PAGE
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The Committee had in co-operation with them in their investigations and deliberations the valuable assistance of Dr. C. Childs, Mr. Felix Clay, Dr. Clement Dukes, Miss Findlay, Miss Ravenhill, Dr. Rivers, Mr. J. Russell, Dr. C. Shelley, and Dr. Sydney Stephenson.

On the presentation of the last year's report of the Committee at the meeting of Section L two suggestions were made as to matters for the special consideration of the Committee. Miss Findlay suggested inquiry by the Committee into 'the need for appointment of women-inspectors' for schools. Professor Armstrong, President of the Section, suggested the preparation by the Committee of a short treatise on the conditions most necessary to observe for the maintenance of health in school life.

On the assembly of the Committee after reappointment by the Association, both these suggestions were at once taken into consideration. Sub-committees were appointed which undertook to collect information

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on questions on the general problem of school hygiene not dealt with in the previous year. The Sub-Committee on the Essentials of School Buildings have furnished a report which forms Appendix I. in the present report of the Committee. The report thus received forms a condensed *résumé* of the subject of a very practical character. It may be regarded as a contribution toward the realisation of the proposal that a short practical treatise should be drawn up by the Committee. Its conclusions are of a general character and are applicable to all classes of school buildings.

The Sub-Committee on Eyesight in School Children has dealt with and reported on (*a*) the causes of defective eyesight in school children, and (*b*) the conditions requisite for preserving eyesight from injury in school life. Besides dealing with general principles involved, it makes some practical recommendations of much importance. One of these is that it should be required that school books should be 'passed' in respect to their typographic standard and quality by some recognised hygienic authority before being adopted in schools.

The necessity for a very considerable eye-working distance in all the exercises and instruction imposed upon young children is a condition which lies at the root of school hygiene.

The report of the Sub-Committee forms Appendix II. of the present report.

The Sub-Committee that undertook the collection of information regarding the question of need for appointment of women-inspectors to schools has gathered valuable evidence. The general line of their inquiry was directed to obtaining authentic instances of reforms that would earlier have gained attention had the school where the reform was needed been visited by a competent woman-inspector. The report given forms Appendix III. to the present report. Considering that in school life the two sexes in about equal numbers are engaged in teaching and being taught, the inspection should, it is obvious, theoretically fall under the charge of men and women in about equal extent. What the report of the Sub-Committee does clearly show is that such a division of the responsibility is practically demanded because in certain respects inspection by women-inspectors possessing the necessary qualifications and training as indicated in the report is the most likely to ensure satisfactory control and prompt remediation of certain difficulties.

APPENDIX I.

Notes on the Essentials of School Buildings.

In drawing up the following remarks upon school buildings in relation to health the Sub-Committee had before them the regulations issued by the Board of Education both for elementary and secondary school buildings. As these are open to anyone, and give a large amount of detailed instruction as to the planning and fitting up of both classes of schools, it seems better to the Sub-Committee to confine themselves to some general observations applicable to all classes of school buildings, avoiding as far as

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possible details applicable to particular classes of schools, which can be readily obtained from the regulations mentioned above

Generally.—The plan or general scheme of the building should be arranged with a view to providing for the particular system of organisation and routine that is intended to be adopted in the school.

The main points to be kept in view are simplicity and directness, that is to say, narrow corridors or passages are to be avoided; all parts of the building and playgrounds should be easily overlooked, so that the duties of supervision may be reduced to a minimum. There should be no buttresses or projecting parts of the building to form corners or places screened from observation.

Every part of the inside should be thoroughly well lighted.

The staircases should be planned so that there is easy and direct access from every part of the building to the open air, and so distributed that no part of the building can be cut off by fire; they should be arranged to discharge into open places of sufficient size to prevent jostling or crowding in case of two or more classes being dismissed at the same time. The general scheme must provide for rapid and orderly movements of large numbers and easy accessibility to every part of the building for the principal.

In the case of large boarding schools, the residential buildings should be kept separate from the educational block; in this way each boarding house may be placed so as to have the most favourable aspect, can be more easily isolated in case of sickness, and the air can be allowed free play all round.

The objection to arranging a school in the form of a quadrangle is that there will necessarily be a certain amount of stagnant air, and that only two sides can have a favourable aspect.

Site.—A damp or low-lying ground should be avoided—if possible a position on the top or side of a hill facing south with a gravel, sand, or chalk soil, sheltered to the north and east by trees, preferably pines. Ground water should not come within about 10 or 12 feet of the surface. The advantages of a good soil, such as sand or gravel, may be entirely neutralised by an impervious layer of clay a little below the surface.

The erection of a school building upon made ground is very undesirable.

In towns care should be taken to place the school away from main or noisy thoroughfares, the neighbourhood of railways, factories, or any industries causing dust and smell. A wide street with the houses on the opposite side low should be chosen, both for light and the avoidance of noise. Otherwise, unless the building can be put at least 60 feet back from the street there will be disturbance to the work. In any case the room where noise is of less importance, such as studios, laboratories, cloak-rooms, staircases, corridors, and the assembly hall, should be placed on the street side, aspect having been taken into consideration. Double windows should only be allowed where there is an effective and complete independent system of ventilation. The places that the children may have to pass on the way to school should also be considered when settling the position of a school.

Aspect.—The building must be placed so that the sun has free acces to every part that is in constant use. The best aspect is probably south-east: this allows the morning sun to shine into the room while it is off before the hot part of the day. Rooms facing due west will be very

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hot in summer, and should if possible be only used in schools where work is not carried on in the afternoon. It is suggested that on a free site the best plan will be to place the side of the hall in which the windows are (in a school on the central hall plan) to the north-west, placing the studio at the north end and grouping the class-rooms on the south and east.

Entrances.—In arranging the entrances regard should be had to the prevailing wind in order to provide shelter; there should be covered space for early comers to wait in on wet mornings. They should not open directly into the hall, nor be used for cloak-rooms. A strong draught is produced when two entrances open opposite to each other with a straight corridor between. In mixed schools there must be a separate entrance for boys and girls.

Cloak-rooms must be large, airy, and well lighted, and placed so that they are under easy observation from outside. They should be easily reached from the main entrances, and the doors so arranged as to allow the various forms of cloak-room drill that are customary in the elementary schools. The stands should be some distance apart with 12 inches between the pegs, of which there should be only one row, so arranged that the clothes can hang clear away from the wall and allow of the proper circulation of air. In the case of boys' schools less space will be required. The best umbrella holders are the 'turnstiles.' Cloak-rooms should be warmed, and special attention be paid to their ventilation. Lavatory basins should not be placed in the cloak-rooms.

Class-rooms—

(*a*) Area. The area of the floor space to be occupied by the pupils should be not less than 18 square feet per child.

(*b*) Lighting. The main light to be from the left, other windows being subsidiary and for the purpose of ventilation.

The transparent glass surface should be, if possible, one-quarter of the floor space to allow for the dark days, and should never, even on the south side, be less than one-sixth.

The sill of the window should not be more than 3 feet 6 inches from the floor, but if higher should be bevelled off.

The glass should be carried as near the ceiling as may be constructionally possible.

The piers between the windows should be as narrow as possible, and splayed or bevelled off.

The back row of desks must not be placed behind the last window. Transoms or heavy mullions should not be allowed even if the requisite amount of glass area is provided, as they cast shadows. The colour of the walls is important with regard to lighting. The light yellows and buffs often found and recommended are not satisfactory, yellow in particular producing fatigue and nervousness in a marked degree as compared with other colours. Some light shade of green or grey seems on the whole the most satisfactory colour. Blackboards placed at a height within easy reach of the children should run round the walls.

Sleeping-rooms.—The most satisfactory arrangement is probably that of open dormitories containing a moderate number of beds. The cubicle system is less to be recommended, while that of having rooms for two or three should be unhesitatingly condemned.

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Not less than 65 square feet of floor area should be provided for each occupant.

Playground.—Every school should be provided with sufficient open space immediately round the school building for the purpose of a playground: this should in no case be less than 30 square feet per head. In the case of secondary schools this should be in addition to the playing field for regular games. Boarding schools require considerably more space than day schools.

Ventilation.—The Committee while feeling to the full the enormous importance of the subject of proper ventilation in regard to the success of the school, both as to the mental and physical development of the pupils, feels some difficulty in offering any suggestions as to how a satisfactory result can be secured. Many schemes are put forward, both 'mechanical' and 'natural,' each of which claims to secure perfect ventilation, but all of which in actual practice fall far short of their promises. The Committee would, however, like to utter a word of warning with regard to certain systems that rely on the introduction of hot air both for the warming and ventilation of the rooms. Such a system may work well enough in the case of one or two large rooms, but in a school with its large number of rooms with an always varying number of occupants the difficulty of adjusting the pressure becomes very great. The continual movement and opening of doors is also apt to interfere with the proper working of the system; in addition to this there is the breathing of the warmed air. In winter the incoming air must be raised to a considerable temperature to allow for the cooling effect of the windows, walls, &c.; and although somewhat cooled down by the time it reaches the pupils it must, it would seem, lose most of its invigorating qualities, even though it has not been heated sufficiently to burn the organic particles present. Rooms heated by hot air are apt to have an enervating and debilitating effect. In order to warm and ventilate a room by hot air only it is, of course, necessary to introduce the fresh air at the top, extracting the foul air at the bottom. This, again, is open to several objections: those sitting near the outlets are in a continuous stream of all the bad air in the room; the breathed air is brought down again past all the people in the room (as are the products of combustion if artificial light is in use); the windows can never be opened because if they were the whole working of the system would be upset; finally, in summer, when the incoming air is cooler than that in the room, there is a tendency for the entering air to fall straight down to the outlet below. This system has undoubtedly many strong supporters, but the unsatisfactory state of things existing in many schools where it has been installed has induced the Committee to urge that a good deal more experiment and experience of it is required before it can be safely recommended. On the whole, it seems that the solution is likely to be found in some plan by which the fresh air (warmed when the weather is cold so that it can be freely introduced without discomfort and maintained at a temperature of not less than 55°) is brought in at a low level, the foul air being taken off at the highest point (mechanical power being used to make sure of sufficient movement) and the actual warming of the room being done by some form of direct radiation.

Sanitary.—The sanitary conveniences in boys' schools may well be placed outside the main building; but in girls' schools, and where there are very young children, they must be provided in the main building, but

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should be cut off by a properly arranged ventilating lobby. This part of the school building should be thoroughly well lighted, so as to ensure its being kept properly clean. Deodorants or disinfectants should not be allowed, as they take away one certain and easy means of detecting anything wrong. To prevent unpleasantness reliance should be placed on perfect cleanliness. Frequent inspection by the principal is of the greatest importance, as when these matters are left entirely to the school-keeper it is not uncommon to find in schools otherwise splendidly equipped and managed a very undesirable state of things. In planning a school great care should be exercised as to the position of lavatories, &c. No windows in the main building should overlook the approach to them.

APPENDIX II.

Eyesight in School Children.

The Sub-Committee appointed to inquire into the recorded investigations as to (A) the causes of defective eyesight in school children, and to give an account of (B) the conditions necessary for preserving the sight in school life, reports as follows :—

(A) The three principal *preventable* causes of defective sight in schools are found to be—

1. Defective and flickering lighting of school buildings and rooms.
2. Faulty positions of scholars with regard to light and with regard to the work upon which they are occupied.
3. Bad type of print and writing, both in school books and upon blackboards.

To these may be added causes less under the control of the school, though definitely affecting the child in its relation to school life, namely—

Defective nutrition ;
Insufficient sleep and clothing, and home habits and conditions injurious to general health ;
Home lessons conducted under unfavourable conditions of light position.

(B) The three conditions necessary for preserving the sight in school life are found to be—

1. That the schoolroom and classrooms should be sufficiently and steadily lighted, whether by daylight or by artificial lighting.
2. That scholars should maintain correct positions in school, both in regard to the direction of the light falling upon their work and correct posture and with regard to the books or objects upon which they are at work.
3. That the paper and type of all books used in school should be appropriate. Blackboards should be properly prepared and placed, and the writing upon them clear and of a suitable size. Slates of the ordinary description should be abolished or replaced by others of a more modern kind.

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1 A. A classroom is considered to be sufficiently lighted by daylight[1] in all parts in which a portion of the sky is visible by the scholar; by artificial light when small type known as *brilliant* can be read in any part of the room at the distance of 18 inches from the normal eyes. In place of blinds a sliding screen covering only part of the window should be arranged so that sunlight may be prevented falling directly on the scholars, and that with a minimum loss of daylight. Windows should always be carried as near to the ceiling as possible so as to secure the largest amount of sky. The height of the window-sill from the floor also requires careful consideration. It should never be so low as to cause dazzling of the scholars' eyes.

The window-glass should be perfectly clear without any muffling or clouding, not only on account of securing the largest amount of light, but to save the check to the eye-nerve of thwarted vision. Windows ought not to be broken up by bars where these can be avoided; and plate-glass is preferable, where possible, as being a good non-conductor. It retains the heat of the fire in the room, and also takes the heat out of the sunlight entering the room. Careful attention should be paid to the ratio between window area and floor space.

Reflected light from the ceiling becomes well dispersed and is steady.

2 A. The correct position for a child, when sitting at a desk to write, is such that his feet may be firmly planted on the floor or foot-rest, the seat of his chair reaching forward to his knee, the back of the seat supporting both middle spine and shoulders. The front of the desk should come well over the knees and be at such a height that both arms can be laid on it easily without raising the shoulders. The slope of the desk should be about 30°, and this position will be found to bring the paper at about the distance of from 18 to 20 inches from the eyes of the normally proportioned child.

In reading the slope of the book should be 45°; and this exercise should for the most part be taken sitting rather than standing in order not to dissipate nervous energy from intelligence and eyesight; and great liberty of movement must be allowed within these requirements, either when standing or sitting, to avoid strain upon the delicate nervous organism.

Desks and seats must be so placed that light falls from above (dispersed light causing no shadows) or from the left. Light must be steady and not flickering, and must fall upon the work and not upon the eyes of the worker.

3 A. School books are considered to be appropriate and well printed when the paper is thick enough to prevent the ink showing through; the colour of the paper slightly toned white, not glazed; the ink a good black; the size of type pica leaded; and the length of line about four inches.

A feeling is expressed by many that school books should be 'passed' by some hygienic authority as appropriate to eyesight before being received in schools from the publishers.

Blackboards should be slated black to receive the white chalk. They should be at a maximum distance of 30 feet from the observer, should be well illuminated, and the writing upon them should be well spaced and not less than an inch depth.

[1] Special instruments have been devised to measure exactly the amount of daylight in any part of the room.

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As while hypermetropia (longsightedness) is generally congenital, myopia (shortsightedness) is generally acquired. The simple methods adopted for discovering defective eyesight in its early stages and maintaining an alertness in observing an increased deficiency are as follows :—

An examination of the eyes in any case where a child appears to be stupid; tends to hold the book or object at which he is set to work too near his face; cannot see the blackboard so easily as his comrades; complains of headache, seeing 'colours,' or has watering or redness in the eye, or squints.

The examination of all children over the first standard annually by means of Snellen's letter test, or by tests of broken circles or incomplete squares. Anything more complex has been found to be misleading except when used by experts. In the use of Snellen's letter tests, daylight being variable, it is desirable to arrange a couple of argand burners or electric lights so that the types shall be thoroughly illuminated while the lights are screened from the child under observation. But it should be remembered that the test so conducted only gives the working power of those eyes under identical conditions in the schoolroom, and it should not be supposed that a less illuminated or less clearly written blackboard will be readable at a similar distance.

Children need to be taught and trained to secure for themselves proper lighting at work, and to maintain proper habits of posture, &c., with regard to light; while remembering that the habit may be the result of eye defects or defects of lighting, teachers should make a point of correcting any tendency to form a mere habit of getting objects close to the eyes, in order to protect the children against loss of eyesight in school life.

Separate classes might be arranged in large schools for high myopic cases. In all cases special attention has to be given to the myopic under the guidance of the oculist.

It might be well to recommend the appointment of a medical man skilled in eye disorders to each large school or group of schools, when all cases of defective sight should be referred to him for examination and report.

APPENDIX III.

Need for Appointment of Women-inspectors.

The Sub-Committee has confined its inquiry chiefly to the need for women-inspectors in elementary schools, in pupil teachers' centres, and in technical institutes. Information has been sought in country schools, in town schools, from head teachers, and also from inspectors. The evidence is of great interest, but naturally of limited extent. No special effort has been made to restrict inquiries to districts where women-inspectors have worked, but on the other hand it has not been possible to prosecute inquiries very widely. The general line of inquiry has been directed to obtaining authentic instances of reforms suggested by women-inspectors, and of cases where, in the opinion of the teachers, desirable reforms would have received earlier and more attention had the school been visited by a competent woman-inspector, and this under various heads as buildings,

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sanitary conditions affecting both teachers and scholars, scholastic defects and difficulties, and morals.

Evidence given by inspectors has mainly referred to points in which attention has been drawn by women to such defects in girls' and infant schools, and cases in which teachers have specially sought advice and help from a woman-inspector.

An abstract is appended from a valuable letter from Miss Ravenhill covering nearly all the points of importance that have arisen in the inquiry. The correspondence with teachers, inspectors, and others has been of great interest, and the Committee only regret that it is not possible to print fuller extracts.

It should perhaps be mentioned that while not all teachers are in favour of having women-inspectors, it seems that it is usually those who work under the happiest conditions who have not felt the need. Almost all are glad of the inquiry, and express hopes that it may be acted on, though many are anxious it should not be known that they have given evidence. The need is as great, if not greater, in pupil-teachers' centres and in science schools for girls as anywhere. One woman, twelve years member of a School Board, writes that women-inspectors will be more needed under the Education Act than before.

Stress has been laid by several correspondents on the care desirable in selecting women to serve as inspectors, and the Committee wish to emphasise this point. It is most important that inspectors, whether men or women, should possess a practical knowledge of hygiene, especially as regards school structures and child-life. Some evidence of such knowledge might well be required in the future.

It is earnestly hoped that the attention, both of the Board of Education and of the new Local Education Authorities may be drawn to the importance of the subject.

Extract from Letter from Miss RAVENHILL *referring to Returns obtained by her from School Teachers.*

'Instances of very serious defects in the ventilation and heating of elementary schools appear in my returns; for example, classrooms underground, of which the air is always foul, and another case where the temperature of the babies' room was rarely above 48° F. for some weeks in the winter of 1902. It is believed that a woman-inspector would be more alive than male inspectors have shown themselves to be to the deteriorating influences exercised upon health by these and similar conditions of work. A glaring example of insanitary conditions is given in a school a portion of the foundations of which stand in water: fungus grows abundantly beneath the school floor, causing an unpleasant odour, but the only steps taken to remedy the evil is the placing of lime from time to time under the floor.'

The information collected this year again, as last year, emphasises the need for and the importance of a greater diffusion among teachers and among those who have charge of schools, of a true knowledge regarding the working of the healthy body and mind. As to this knowledge required by teachers the influence of school habits and of school work

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upon health, the proper care of sight and hearing and of the muscular sense and powers, the regulating of sanitary conditions in warming, lighting, ventilation, and cleanliness both of rooms and of persons, attention to clothing, safeguarding against fatigue—all these are duties for which authorities should encourage the teacher to acquire knowledge and training to undertake them adequately. Suitable instruction in the principles and practice of modern hygiene can alone equip the teacher to perform such duties intelligently. Modern hygiene utilises the sciences of chemistry, physics, and physiology, and from these it welds together an applied knowledge devoted *ad hoc* to the regulation of the conditions promoting health of body and determining to a large extent that of mind also. It is not the whole of the wide study of hygiene that is required for the purposes of the school teacher. It is a knowledge of hygiene devoted *ad hoc* to the conditions of school life. This should be regarded as a *conditio sine quâ non* for those who have the care of children and the working management of school life. This requirement has been forgotten by the framers of the Education Acts. It is not for one moment to be thought that it is the acquirement of any *medical* knowledge that we are urging as necessary for the professional equipment of school teachers and inspectors. The study of chemistry, physics, and physiology is, it is true, at the basis of medicine as well as of hygiene; but the daily routine of the teacher's supervision of maintenance of health conditions in the school would not take the place of a skilled expert's advice and the opinion of the medical man required at stated intervals or as occasion arose. The former would, however, most usefully and importantly co-operate with the latter. Teachers well and practically instructed in hygiene would provide an organisation able to co-operate intelligently with medical advisers. Dr. Kerr in his recent Report as Medical Officer of the London School Board writes: 'The definite requirement of hygienic knowledge as part of the equipment of every teacher is a necessity if a great part of the work of this department is not to be useless in result. Praiseworthy as are the efforts of head teachers to comply with all requirements and instructions, zeal cannot replace knowledge; and until this knowledge becomes a necessity for qualification as a teacher it would be well if special importance were attached to its possession in any future appointments to the headship of departments.'

The Committee in this belief desire to urge the Association to memorialise the Education Department (1) to adopt or recognise some more thorough and practical test of a teacher's knowledge and experience of the application of health conditions in school life; (2) to protect health in school life by making practical knowledge of hygiene as applied to school life an essential qualification for those to whom it intrusts its school inspection.

The Committee desire to be reappointed, and ask to be allowed to use the unexpended portion of this year's grant.

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Corresponding Societies Committee.—Report of the Committee, consisting of Mr. W. WHITAKER (*Chairman*), Mr. F. W. RUDLER (*Secretary*), Sir JOHN EVANS, Rev. J. O. BEVAN, Dr. HORACE T. BROWN, Dr. VAUGHAN CORNISH, Dr. J. G. GARSON, Mr. T. V. HOLMES, Mr. J. HOPKINSON, Professor R. MELDOLA, Dr. H. R. MILL, Mr. C. H. READ, Rev. T. R. R. STEBBING, *and* Professor W. W. WATTS. (*Drawn up by the Secretary.*)

THE Corresponding Societies Committee have to report that at their suggestion, since the last meeting, the Council of the British Association have resolved to recommend to the General Committee that the work at present entrusted to the Secretaries of the Sectional Committees under Rule 10 (p. xxxvii of the last Report) shall henceforth devolve upon the Organising Committees. The effect of this alteration will be that the Organising Committee of each Section will transmit to the Secretaries of Sections, and through these to the Secretaries of the Conference of Delegates, any recommendations bearing upon matters in which the co-operation of the Corresponding Societies is desired. It is hoped that by this means the Organising Committees will specify what local work can be usefully undertaken by the Corresponding Societies, with the view of assisting the various scientific Committees of the Association.

The Council of the Association, at the instance of a Committee which they appointed to consider the relation of the Corresponding Societies to the Association, have directed that an official invitation should be addressed to the various Societies, through the Corresponding Societies Committee, asking them to appoint standing British Association Sub-Committees to be elected by themselves with the object of dealing with all those subjects of investigation common to their Societies and to the British Association Committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres.

For further consideration of these subjects a Conference was held on June 24 between the Committee of Council and the Corresponding Societies Committee, when it was decided that the questions raised in the Report of the Committee of Council should be brought forward for discussion at the Conference of Delegates at Southport.

The following circular-letter was accordingly addressed to the Presidents, Secretaries, and Delegates of the various Corresponding Societies ;—

'Burlington House, London, W.,
'June 24, 1903.

'DEAR SIR,—We are directed by the Council of the British Association for the Advancement of Science to suggest to your Society the advantage of securing closer co-operation with the Corresponding Societies Committee by the appointment of a Special Committee to deal with such subjects of investigation as are common to your Society and to the Committees of the British Association. Such an organisation, it is believed, might be of great use in creating and sustaining local interest in scientific work and in increasing the scientific activity of your Society.

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'The subject of Scientific Education in relation to the Corresponding Societies has been under the consideration of a Committee of the Council of this Asssociation, and that Committee have expressed the opinion that immense benefit would accrue to the country if the Corresponding Societies, in addition to their present work, were to take advantage of the expert knowledge of many of their members to secure adequate representation for scientific education on the Education Committees now being appointed under the new Act. The Educational Section of the Association having been but recently added, the Corresponding Societies have not had much opportunity for taking part in this branch of the Association's work, and in view of the reorganisation in education now going on all over the country the Committee are of opinion that no more opportune time is likely to occur for the influence of scientific organisations to make itself felt as a real factor in national education. They do not at present think it desirable to formulate any definite scheme by which the Corresponding Societies might be of service to the cause of scientific education. Some Societies might prefer to form Educational Consultative Committees, and to place their services at the disposal of the Education Authority of their County or Borough. Others might prefer that individual members of their Societies should be added to the Education Committee; and others again might prefer to act indirectly by helping to foster public opinion in favour of that kind of education which it is the chief function of a scientific body such as the British Association to promote.

'We are directed by the Council of this Association to invite your Society to express its opinion on this subject through its representative at the next Conference of the Delegates of Corresponding Societies, which will be held at Southport on September 10 and 15, during the Meeting of the British Association, when the matter will form a specific subject for discussion.

'For your fuller information a copy of the Report of the Committee of Council of the British Association is enclosed herewith.

'We are, Sir, yours faithfully,

'F. W. RUDLER, Sec. Corresponding Soc. Com.;
J. G. GARSON, Asst. General Secretary.'

The Committee have to report that the returns received from the Corresponding Societies show that in some instances good work is being accomplished locally, though in most cases only to a very limited extent. In reply to a Circular of Inquiry, eighteen Societies state that they have done something during the past year in the way of original investigation. The subjects which have received most attention relate to geological and botanical research.

A Circular similar to that which was printed in last year's Report (p. 863) was addressed to the Secretaries of the various Committees of the Association and others desirous of obtaining the co-operation of the Corresponding Societies, inquiring what assistance had been rendered by the Local Societies. It is unfortunate, however, that the replies to this inquiry have not been of a very encouraging character.

The Elgin and Morayshire Literary and Scientific Association has been added to the list of Corresponding Societies; the Cardiff Naturalists' Society and the Natural History Society of Glasgow have been replaced; and the West of Scotland Marine Biological Association has withdrawn.

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The Committee recommend the continued investigation of the various subjects set forth in last year's Report (pp. 852, 853), with the addition of meteorological observations, including especially records of rainfall.

With regard to the attendance of Delegates at the Conference, it is desirable to point out that each representative is expected to be present at *both* meetings. As a matter of fact, however, many absent themselves from one of the two meetings, whilst in several cases the Delegate fails to attend either. This was conspicuously the case at Belfast.

The Committee greatly regret that considerable delay arose in the issue of the Report of last year's Conference. This delay was due to the failure of the shorthand writers at Belfast to send in any Report of the meeting.

Several valuable suggestions as to subjects suitable for discussion at the Conference of Delegates have been received, and the Committee have decided that at the Southport Conference the following subjects shall receive discussion :—

1. The work of the Corresponding Societies in relation to scientific organisation.
2. The botanical survey of counties.
3. Exploration and registration work for county Local Societies.

Report of the Conferences of Delegates of Corresponding Societies held at Southport, September 1903.

Chairman . . .	W. Whitaker, B.A., F.R.S.
Vice-Chairman . .	Rev. J. O. Bevan, M.A., F.S.A.
Secretary . . .	F. W. Rudler, F.G.S.

The Conferences were held on Thursday, September 10, and Tuesday, September 15, at 3 o'clock P.M., in the Chapel Street Congregational Schools.

The following Corresponding Societies nominated Delegates to represent them at the Conferences. The attendance of the Delegates is indicated in the list by the figures 1 and 2 placed in the margin opposite to the name of each Society, and referring respectively to the first and second meetings. Where no figure is shown it will be understood that the Delegate did not attend.[1]

List of Societies sending Delegates.

		Andersonian Naturalists' Society .	Rev. A. S. Wilson, M.A., B.Sc.
		Bath Natural History and Antiquarian Field Club.	Rev. C. W. Shickle, M.A., F.S.A.
1		Belfast Naturalists' Field Club . .	Professor Gregg Wilson, D.Sc.
1		Belfast Natural History and Philosophical Society.	Professor Gregg Wilson, D.Sc.
1	2	Berwickshire Naturalists' Club . .	G. P. Hughes.
		Birmingham and Midland Institute Scientific Society.	C. J. Watson.
1		Birmingham Natural History and Philosophical Society.	Herbert Stone, F.L.S.
		Buchan Field Club	J. F. Tocher, F.I.C.

[1] The attendances are taken from the Attendance-Book, which each Delegate is expected to sign on entering the Conference.

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1		Caradoc and Severn Valley Field Club	Professor W. W. Watts, M.A., M.Sc.
1	2	Cardiff Naturalists' Society . .	Principal E. H. Griffiths, F.R.S.
1		Chester Society of Natural Science, Literature, and Art.	A. O. Walker, F.L.S.
1	2	Croydon Natural History and Scientific Society.	W. F. Stanley, F.G.S.
		Dorset Natural History and Antiquarian Field Club.	Vaughan Cornish, D.Sc., F.R.G.S.
1	2	East Kent Scientific and Natural History Society.	A. S. Reid, M.A.
1	2	Elgin and Morayshire Literary and Scientific Association.	Dr. Wm. Mackie.
1	2	Essex Field Club	F. W. Rudler, F.G.S.
1	2	Glasgow Geological Society . .	J. Barclay Murdoch.
1	2	Glasgow Natural History Society .	Peter Ewing, F.L.S.
		Glasgow Royal Philosophical Society	Professor Archibald Barr, D.Sc.
1	2	Halifax Scientific Society . . .	W. Ackroyd, F.I.C.
1		Hampshire Field Club and Archæological Society. .	Rev. A. G. Joyce.
1	2	Haslemere Microscope and Natural History Society.	Hon. Rollo Russell.
	2	Hertfordshire Natural History Society	John Hopkinson, F.L.S.
	2	Holmesdale Natural History Club .	Miss Ethel Sargant.
1	2	Hull Geological Society . . .	G. W. Lamplugh, F.G.S.
		Institution of Mining Engineers .	Professor Henry Louis, M.A.
1	2	Isle of Man Natural History and Antiquarian Society.	Rev. S. N. Harrison, B.A
1		Leeds Geological Association . .	A. R. Dwerryhouse, M.Sc.
		Leeds Naturalists' Club and Scientific Association.	Harold Wager, F.L.S.
		Liverpool Engineering Society . .	Professor H. S. Hele-Shaw, F.R.S.
1	2	Liverpool Geographical Society . .	Captain Phillips, R.N.
	2	Liverpool Geological Society . .	Joseph Lomas, F.G.S.
		Manchester Geographical Society .	Joel Wainwright.
1		Manchester Geological and Mining Society.	James Tonge, F.G.S.
1	2	Manchester Microscopical Society .	F. W. Hembry, F.R.M.S.
1		Manchester Statistical Society . .	Professor S. J. Chapman, M.A.
		Midland Counties Institution of Engineers.	Professor H. Louis, M.A.
		Midland Institute of Mining, Civil, and Mechanical Engineers.	G. B. Walker.
	2	Norfolk and Norwich Naturalists' Society.	Frederick Long.
1	2	North of England Institute of Mining and Mechanical Engineers.	John Gerrard.
1		North Staffordshire Field Club . .	Dr. Wheelton Hind, F.G.S.
		Northumberland, Durham, and Newcastle-upon-Tyne Natural History Society.	Professor M. C. Potter, F.L.S.
1		Nottingham Naturalists' Society .	Professor J. W. Carr, M.A.
		Paisley Philosophical Institution .	William Peattie.
1	2	Perthshire Society of Natural Science	A. S. Reid, M.A.
1		Rochdale Literary and Scientific Society.	J. R. Heape.
1	2	South-Eastern Union of Scientific Societies.	Rev. R. A. Bullen, B.A.
1		Southport Literary and Philosophical Society.	A. H. Garstang.
		South Staffordshire and East Worcestershire Institute of Mining Engineers.	Professor Henry Louis, M.A.
		Tyneside Geographical Society . .	Herbert Shaw, F.R.G.S.

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		Warwickshire Naturalists' and Archæologists' Field Club.	William Andrews, F.G.S.
1	2	Woolhope Naturalists' Field Club .	Rev. J. O. Bevan, F.S.A.
1	2	Yorkshire Geological and Polytechnic Society.	Professor P. F. Kendall, F.G.S.
1	2	Yorkshire Naturalists' Union . .	W. West, F.L.S.
1		Yorkshire Philosophical Society .	Rev. W. Johnson, B.A.

First Conference, September 10.

This Conference was presided over by Mr. W. Whitaker. The Corresponding Societies Committee was represented by Mr. Whitaker, the Rev. J. O. Bevan, the Rev. T. R. R. Stebbing, Professor W. W. Watts, Mr. J. Hopkinson, and Mr. Rudler.

The Report of the Corresponding Societies Committee was read.

The Chairman, after some introductory remarks, said that the Conference was honoured by the presence of Sir Norman Lockyer, the President of the Association, who had kindly promised to address the Delegates on the necessity of organising science, with special reference to the question whether the British Association can help in any way, and, if so, whether the Corresponding Societies could take any part therein.

Sir Norman Lockyer spoke as follows: I should like to say that my object in asking permission to attend this meeting was to listen, and not to talk. I have never had the privilege of attending a meeting of the Delegates before, and I was very anxious indeed to be allowed to follow the discussion, in order that I might inform myself as to the views of the Delegates themselves regarding some lines of the work of the British Association which I ventured to refer to last night. My own opinion is that in all these matters the principle of organic growth should be utilised as far as possible; and you may remember I suggested in my address that if the British Association in its wisdom determines to take any action at all in regard to the formation of a Guild of Science, which I hold would be one of the most important things which students of science should do at the present time, it is important to see whether or not that could best be done in connection with the existing organisation of the Corresponding Societies. It is stated in the reports, and I cited it in my address, that there are seventy societies affiliated to the British Association, and that the membership is something like 25,000. I went on to suggest in my ignorance possibly, that we might very largely increase that number both at home and abroad, so that ultimately we should have a very large membership. The reason I ventured to make that suggestion was that I felt the present moment was very opportune for the formation of such a body, because you have throughout the kingdom, from Land's End to John o' Groats, a great number of Councils—county councils, city councils, town councils, district councils, parish councils, and goodness knows what—and it struck me that if we could manage somehow to influence the debates of these bodies, it would be very much better for science, and ultimately, I think, very much to the benefit of the Association. I am a very humble person, a very hardworking man, and I have been working for the last forty years to try in my little way to get adopted some better views of science in this country. Well, I am a miserable failure, and all the people who have made similar endeavours are like me—miserable failures. We have done absolutely nothing. So far as my experience goes, all the attempts made by individuals during the last forty years—

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I can go back forty years in my own work—have been practically of no effect, and that was the reason why I thought it was possible that by some such organisation as I sketched last night we might do something better. That 'something better' is, to put it plainly, looking after votes. Unless we can control votes in the House of Commons and in the Councils throughout the country science will not be any better looked after. If we can control votes science will be benefited; and scientific bodies from one end of the country to the other, working with a goal in view, would be a most important factor in our future national life. Of that I am perfectly convinced; but I am only an individual, and therefore I asked permission to come and listen to you, gentlemen, who have had more experience than I can claim to have, representing as you do different societies, familiar with the conditions in your own localities, and therefore able to say whether it is possible to influence Councils, and gradually to infuse a scientific spirit into the county councils, the town councils, and the district councils of England. I would, therefore, if you will allow me, sit down and listen to what any of you may choose to say with regard to the possibility—or the absurdity—of attempting to carry out this thing.

The Chairman: I am sure we all thank Sir Norman Lockyer for coming and speaking to us to-day, and for his address of last night. It shows his confidence in the scientific societies of the country and his feeling that the local societies might do some good work in helping on the object he has in view. Our various societies are very differently placed, and it is quite possible some of the societies may feel that they cannot do anything, while others may be in a position to influence local opinion very considerably in educational matters. There must be great differences in these matters, and I hope you will enter into the discussion from the standpoint of your own local circumstances, so that we may know the kind of feeling prevailing in different localities, the difficulties in the way, and possibly the manner with which something can be accomplished. Of course there will be difficulties in the way. It is part of a great controversy; but the country being waked up, as it were, on the subject of education on a scientific basis, I am sure you will all agree with our President when he says that now is the appointed time, and it is best to strike while the iron is hot. The year before us is just the time when educational matters can best be pushed forward.

Principal E. H. Griffiths, F.R.S. (Cardiff Naturalists' Society): I rise to speak as a member of a local society, though I cannot confine myself to that point of view, and would venture to take a wider survey, and say how the matter may be viewed in that part of the country in which I am most interested, the Principality of Wales. I think I may claim to have some right to speak on this matter, for I am a member of several educational authorities in South Wales, and happen at the present moment to be the Vice-Chancellor of the University. I heartily agree, from the local college or university point of view, that we can do something if we all work together. But I have, as some of you know, some hesitation or doubt as to the best line on which our energies can be expended. I am not sure whether the subject is so advanced as it may appear to some of you. What we have to do is to educate the 'man in the street,' and convince him that pure science is a good thing for him, and then all our difficulties will be swept away. We want to be able to

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go to him and say that the men who are working in the laboratories and have laid the foundations of the discoveries he uses in his daily life are men who touch him very nearly and help on his prosperity very greatly. That is the kind of missionary effort in which I believe every one of our societies can heartily join. I have given a little attention lately to this line of public advocacy in my own district, and I have found men, particularly working men, very willing to listen to such arguments, and if we can place before them definite examples, showing them, for instance, in regard to electricity, how much Faraday working in his laboratory did in preparing the way for them to earn their living, the work will be easy. That will make them see that science is a real thing in their daily lives and an important factor in the prosperity of the country. The first point, then, is to see if our societies cannot act as missionary societies throughout the country in bringing home to the working classes the real, live, not sentimental, business benefits which result from the study of pure science and research. We have the academic professor who loves and talks about the work, and we have the 'man in the street' who takes a peculiar pride in declaring that he is a practical man; but there is no one to act as a go-between, bringing the two together, and showing that, after all, theory is a real and practical thing. There is a danger at the present moment, when academic fiscal questions are being so much discussed, of getting entangled in one or other of the great political parties. If we take part in the discussion, and back any definite policy, there is great danger of the want of wisdom of the few wrecking the success of the whole movement, or doing untold injury for a long time to come. It is very necessary, therefore, that we should pay particular attention to our steps, and carefully avoid, as our President so admirably did last night, any reference or assumption which can be put down to political views or political advocacy. If it is possible to frame a line of action in that way we shall keep clear of political entanglements, and we shall have the opportunity and the power of securing some of the objects we have in view. I venture, with the greatest diffidence, to differ from our President as to putting forward our object so prominently. It is quite true we want to catch votes, but if we start out with that as our avowed object we shall lessen our chance of success. Let us appeal to the 'man in the street' on the facts which must convince him that science is of abiding benefit to him in his daily life. Let us get him imbued with that idea, and votes will follow.

Mr. W. F. Stanley (Croydon Natural History and Scientific Society): Principal Griffiths has spoken about the 'man in the street,' but if we could just commence the study of science with the 'boy in the street' we should be getting a step forward. As long as our schools adhere to the one simple rule of teaching reading, writing, and arithmetic according to the old original code, which has been relaxed only very little, we shall never get a taste for science among our population. I have noticed that after teaching the children reading, writing, and the old-fashioned arithmetic, together with a large amount of grammar—much more than I ever acquired myself—they develop a taste for a certain class of literature, and many of these scholars become writers for the penny journals. If we had taken the same amount of pains to give these children educational tastes as I have seen done in Norway and in Germany it would have been much better. I should like to see the children in our schools taught the things which surround them, and the principles of

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those things, for if once a boy is taught these things he takes a violent interest in them, more so than one would imagine. Any little chemical experiment greatly interests a boy. If you show him the escapement of a watch, he will at once take an interest in clocks, and he will have gained his first taste in the rudiments of mechanics. Teach him a little about electricity, and he will take a great interest in that subject: he will spend his pocket money in buying an electric bell for the cottage, or knock one together for a shilling or so, and that will give him his start in science. I want to say what we are doing at the present time, and to call the attention of this Conference to it. A large number of our societies exist merely for a certain object. Many of them are collecting societies, botanical or geological, or are interested in photography. We have in my particular district, the Croydon district, some 2,000 students studying science at the polytechnics. If the local societies would affiliate themselves in any way through their committees to the polytechnics, they would be able in some way to draw the strings together in the manner Sir Norman Lockyer has suggested. But what strikes me as being what working men require, and, in fact, what we all require, is to have some initiatory system in order to gain a taste for science. I have been much surprised at the very excellent results of our polytechnics. I am sure anyone who has read or even looked through the papers on science, will say that very able work is being done in my own particular district, which is most gratifying. There are 10,000 inhabitants in the immediate neighbourhood of South Norwood, and we have over 1,200 class entries, which shows that 12 per cent. of the people are taking an interest in science. I think if our societies can affiliate themselves to the polytechnics, and have representatives on the committees of these societies, which, so far as I am aware, are very anxious for their admission, we shall have begun to unite our societies together, and we shall be able to draw them to a focus.

Mr. Garstang (Southport Literary and Philosophical Society): As I have been invited to attend this Conference I will explain what our local society is doing. Our society is about twenty years old, and we have done useful educational work. We have influenced the town council, because in the first instance we started the science and art classes which have since been taken over by the town council; and also another work which is hardly municipal, the University Extension Lectures, which have recently been taken over by an association formed for the purpose, with the result that Southport is now one of the most successful centres in England. After listening to the President's admirable address, I thought how we could effect the particular object of influencing public local opinion. It occurs to me that if local opinion is influenced it will be principally by local organisations influencing the votes of members of local bodies. The President subsequently voiced this particular idea, and I do not see why a scientific society, not associated with any particular party, should not try to influence local opinion in this respect. I hope the scheme will be given a very earnest trial, and that it will be attended with successful results. It seems to me that in municipalities a great object would be achieved if it were possible to influence the opinions of the town councils and the district councils—those bodies which have it in their power to put into force the provisions of the Technical Instruction and kindred Acts relating to the promotion and advancement of science in the locality. As to returning special

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members to a town council, I think that might be a difficult matter, because a member is elected for a particular ward, and you could not possibly get the scientific opinion of a town focussed on a particular ward or candidate. The Southport Society is very pleased indeed to have been able to bring the British Association to Southport, and on behalf of our local Society I heartily welcome the Delegates.

Professor J. W. Carr (Nottingham Naturalists' Society): It may possibly be of some use if I state what we have been doing at Nottingham for some years past. The Nottingham University College, an extremely flourishing institution, well equipped with scientific laboratories and a good natural history museum, really arose out of the efforts of the old local Natural History Society, which managed to get the corporation so interested in scientific matters that they ultimately founded what is possibly the only institution of a university character in this country which owes its inception to the corporation of the locality. As many of you know, we have for many years been doing our best to promote scientific work of all kinds, and I think we may say that we have succeeded in creating a great deal of interest, and that we have some local influence on the constitution of the new educational bodies which are springing up all over the country. Myself and two of my brother-professors have been put on the educational bodies of neighbouring boroughs, and there is a constant demand for advice on such matters as the creation and equipment of scientific laboratories. At the present moment Ilkeston is just considering the question of building a large science school with chemical, physical, and even biological laboratories—a remarkable thing for a borough of less than 10,000 inhabitants. That is the way of attaining the object Sir Norman Lockyer has at heart. We are trying to get hold of the 'man in the street,' and also the children. We have a day department in our college, with 120 students, who come for two years' training, and are replaced by a similar number. Almost the whole of these are to enter on elementary teaching after going through a certain amount of science work. These people then go out into the public schools of the neighbourhood, and endeavour in their turn to create an interest in scientific matters among their pupils. One of the best features of their work is that they are allowed by the education committee to bring their scholars once a week to the University College to inspect the museum, and even the laboratories, and those of us who are able to do so take them round the institution and point out to them the features of special interest, as well as things which have a direct bearing on their work and on the industries and trades of the locality. Further, we supplement our purely academic work by public lectures on scientific subjects specially addressed to working men. We get very large audiences, and the men take a great interest in what we are doing. I believe in that way we are creating a kind of constituency from which we expect to get good results in the future.

The Rev. J. O. Bevan (Woolhope Naturalists' Field Club): We are all very much indebted to our President for opening the discussion on this subject. I have a feeling, however, that the proposition is a little nebulous at present, and before we discuss the matter further I think we should have before us some suggestion of a definite character, around which our thoughts might be suffered to crystallise. But one takes a grain of comfort from the thought that if any Guild of Science be founded under the auspices he suggests, the British Association and the

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Corresponding Societies would have a considerable share in the direction of matters. Apart, however, from all that, it would seem to be the case that even under existing circumstances a great deal might be done. I am aware many opportunities have been allowed to slip in the passing of the Elementary Education Act of 1870, the Welsh Education Act of 1889, the Technical Education Act of 1891, which gave local authorities power to spend enormous sums of money, the Education Act of 1902, and, last year, the London Education Act. These all provide for the constitution of a large number of new bodies, and the collaboration of work in connection with existing bodies, and as matters now stand one would be inclined to believe that, if concerted effort of an intelligent character could be arranged in different neighbourhoods, it might be possible to obtain extended powers. Some of these bodies have technical committees, and to these outsiders are sometimes co-opted, so that there is no reason at all why some concerted effort could not be made by persons, scientific and otherwise, in a neighbourhood in order to provide for the co-operation of all persons well-disposed towards science. Sir Norman Lockyer is disappointed that so little has been done during the last forty years. We all share that disappointment, for it is very real, but I am afraid our present effort is ten or fifteen years too late. Schemes are now being formulated and elaborated, but it is a difficult matter to interfere with the constitution of existing schemes. It has been suggested that, in addition to these various bodies, partly elected and partly co-opted, consultative committees should be formed. I have not much opinion of the value of consultative committees, for the bodies formed by these local authorities would be jealous of allowing such a committee to interfere with their deliberations and the spending of money. They would not be allowed to have a definite voice in the management of their affairs, and in a few years the consultative committee would become practically defunct. One thing to be noticed in relation to this subject is, we are not only concerned with the elementary, but with secondary schools, and it is a much more difficult matter to deal with them, because the organisation of secondary schools is not so complete. There is a third set of schools which present an even greater difficulty, and that is the private schools. Of these there are something like 8,000, in which the boys and girls of a large number of our members are educated, but owing to the lack of organisation it is difficult to effect any change in the course of instruction introduced into these schools. And yet it is a most important matter. Why should not these children be educated in the elementary principles of science? Yet apparently nothing can be done. If a resolution is formulated some of these eventualities may be considered. Further, science is often at a discount in the minds of the public because, as a matter of fact, the science which is taught in some of our schools is, not to put too fine a point on it, no science at all. We want it taught by well-trained teachers, rather than that the children should be crammed with certain facts of science by a teacher who, because he has just taken a course of twelve lessons in agriculture, for example, is supposed to know all about the nature of the soil, the value of manures, the rotation of crops, and so on. As a matter of fact he knows very little, and parents unite in holding him up to scorn. I do not want a cook who can present yards of certificates, and yet spoils my dinner. Science is at a disadvantage. Let us be careful; we not only want science taught, but we want it taught in a proper scientific way.

Professor W. W. Watts (Caradoc and Severn Valley Field Club);

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As President of the Section of Geology I have been making a strong appeal for the teaching of geology in technical colleges and universities, and I have appealed in this way because I consider it a science which can be taught with very little apparatus, it leads to a life in the open-air in its practice, and it is an admirable training in the collection of facts, and of fact pure and simple. More than half the real work—in fact the greater part of a scientific man's work—consists in the collection of accurate facts, and geology affords an admirable instance of a science in which there is a host of new facts waiting to be collected. But no science stops here. It has to collect the facts, and then pick out those which are really of use. It is only the exceptional facts which are illuminative, and from which it is possible to draw hypotheses. In geology one has the constant opportunity of exercising the faculty of theorising, because in this science, perhaps more than in any other, one requires a constant succession of theories. Then I may point out the enormous economical value of this science to the nation as a whole. The population has increased five times since the industrial development of our iron and coal resources commenced. That is entirely due to the development of our mineral resources, which, sad to say, have been and still are being shockingly wasted. The waste in looking for coal, in getting it, and in using it, is appalling. One way of diminishing this will be to stop the waste of exploration, and for this we want better geological education of our engineers and others who have to do with the resources at different stations. Now there are hosts of individuals who have made enormous profits out of this knowledge. In America they are using this knowledge up to the hilt, making use of every observation by the United States Survey and of individuals. These opportunities are being jumped at in every direction—in the search for coal, iron, gas, water, oil, and precious metals; they know that this work is going to bring them wealth, and they encourage it. Very soon they will put us out of the markets entirely. Let us put some of the profit back again in the business and develop it further. It is the knowledge of these facts which has given certain individuals their profit; it has given the State profit and brought it into a prominent position in the world. It seems to me that both the individual and the State should give back some of these savings, in the form of encouraging the acquisition of further knowledge of the resources of the country, because the problems that are going to face us in the future are infinitely more difficult than those of the past. If we are to make as much use as possible of the resources remaining a great expenditure will be necessary. Our national resources should be carefully guarded against the shocking waste of our previous explorations. The spread of a knowledge of geology is one of the ways in which this can be done, and we want the State to help in the matter.

The Rev. W. Johnson (Yorkshire Philosophical Society), said: It may be of interest to hear some of the difficulties which beset the head master of a science school. There is, first, the difficulty with the boy. Unless you can interest boys in science they are unwilling to take up any scientific subject; but if you can convince them that there is a post waiting for them at the end of their school career, they will give themselves to the study of science with considerable zeal. But there is a strong opinion that the only subjects which should be taken are those which are necessary to enable them to enter on one particular profession. Where a scientific subject comes in they will work hard, but if you

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introduce a subject from a pure desire to improve the mind and better the quality of the education you cannot get them to do well. In my school you can divide the boys into two distinct classes—those who pay fees and those who come with scholarships from the elementary or other schools. The dividing-line is very distinct. When we present them for examinations, the boys who come from the schools do us credit, and those who do not are for the most part the sons of parents who pay fees. There is in the minds of the lower middle-class people the belief that education ought to lead to success in life, and that only such subjects should be taken as will fit them to take a useful place in business. One of the heads of an important railway company came to me some time ago, and asked what education I would give his boy. When I told him, he said scientific subjects were useless; what he wanted was typewriting, shorthand, bookkeeping, and commercial correspondence. Thus we have the example of a man in a high position who at once cuts the ground from under your feet by saying, 'Dwarf down my boy, and only fit him for taking a place in my office and working his way to a position under me.' If there are many in the country like that we have not much chance of giving a scientific education. Another difficulty is in regard to the co-optive member for secondary schools. Judging from the action of the committee to which I have been co-opted, I think they intend me to be a sleeping partner, but I need hardly say that that is not my intention. I think it is a great mistake in the Education Bill that the care of scientific education is committed to town councils. It is a mistake to suppose that German secondary education is so much better than that given in England. I have a friend in Bavaria who was recently sent by the Bavarian Government to inspect our science schools. He lived with my brother in Dublin for some time, and then with me in Yorkshire, and he has this year been lecturing in Vienna and elsewhere on scientific education, with pictures of laboratories of English schools. He has had views taken of the Leeds Higher Grade School, my own, and those he saw in London. All these, he says, are in advance of those in Germany, so that we need not be dismayed. We should endeavour to get pressure from the Legislature on the county councils and the town councils, and thus make provision for secondary and technical education. The Societies we represent have been much to blame in not developing a liking for science among the young. You have thousands of specimens in your museums which you can put before your children. You have able men who can lecture to them in the halls of your museums on its botanical, geological, or other features. There has been an excellent use made of the Leeds Museum by its librarian, Mr. Crowther, and myself, and if you have not read any accounts of the work before, I advise you to put yourself into communication with someone in Leeds, and see what is being done there.

The Chairman: I am glad to hear that the polytechnics are doing such good work. The remark that we have not developed science among the young is true generally, but it is not true in every case. At Croydon we have started a junior class of members, and hope it will work well. The young members pass into the society when they attain a certain age; they become full members without any process of election, merely by doubling their subscriptions. That is a point societies may take up in getting hold of the young. If you can offer prizes for collections of photographs or natural objects you will do well. On the whole

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we seem to have had a very good discussion, and I hope you will continue it in your several societies. In approaching your winter sessions bring this before the standing committees, and you will be able to do a great deal of good.

The Chairman then read the following resolution, which, he said, had been passed by every Section that morning: 'That, as urged by the President in his address, it is desirable that scientific workers and persons interested in science be so organised that they may exert permanent influence on public opinion, in order more effectively to carry out the third object of this Association, originally laid down by its founders, viz. "To obtain a more general attention to the objects of science and the removal of any disadvantages of a public kind which impede its progress," and that the Council be asked to take steps to promote such organisation.'

The motion was then put from the Chair and carried unanimously.

Mr. J. Hopkinson (Hertfordshire Natural History Society): I should like to refer to a practical matter connected with this resolution. To make it more widely known the delegates should be asked not only to bring this before their Societies, but to see that it is printed in the proceedings or transactions of their Societies. I hope this will be an effective way of bringing this resolution before the notice of the 25,000 members represented by the Corresponding Societies Committee.

Mr. W. M. Rankin then read the following Paper:

The Methods and Results of a Botanical Survey of Counties.

By W. Munn Rankin, *B.Sc.* (*Lond.*)

During the current year two papers dealing with the Distribution of Vegetation in the West Riding of Yorkshire have been published. These constitute the first instalment of a Botanical Survey of England and Wales. The late Robert Smith, of Dundee, similarly issued two maps dealing with the Edinburgh District and North Perthshire; a third, treating Forfar and Fife, will be published early. Surveys of areas in Westmorland and Somerset are in an advanced state. In all, the survey of over 4,000 square miles has been completed. It will be seen, therefore, that the project on which four or five of us have embarked is no untried venture. On the contrary, the main ground-lines of the research have been established, the values of numerous factors have been weighed, and the significance of a vast number of problems has been grasped. The present time, following so soon on the completion of the two Yorkshire areas, seems most opportune for endeavouring to interest the great body of naturalists in our work, not only passively, but also actively, so that throughout the kingdom the work may be carried on.

Putting the matter simply, the chief object of the survey of vegetation is to reduce to certain well-defined terms the vegetation of a county, and then to examine the biological features of each such term.

The most unscientific observer on a visit to some district new to his experience, and, better, when forming a memory-picture of his own homeland, states the scenery in more or less general terms of geology and botany. He remarks the hills with their crags and glens covered with heather or grass, the valley-slopes strewn with rock débris and thin woods, the broad alluvial river-'bottoms,' in which stand extensive park woods, or the gently undulating plains, rich with cereals, luxuriant hedgerows and

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wooded commons. Descriptions of scenery found in novels and books of travel are constructed on these lines.

Of late years much has been written concerning the causes of scenery, regarded almost entirely from the aspect of the geologist. To us, working amongst the mountains of the Grampians and the Pennines, this view has been extended, and a method has slowly evolved itself of regarding the scenery as a function of the vegetation as well as of the rocks. Nor is this all; further points of view have presented themselves. There is that of the meteorologist, who thinks of plant-life as affected by climate, by sunshine, by elevation; that of the geologist, who notices startling variations of vegetation accompanying changes in subjacent soil or rocks; that of the geographer, who sees in woods and pasture items building up a landscape; that of the agriculturist and forester, who seeks to get the best value out of his land, be it meadow, hill, pasture, or cragside; that of the economist, who sees one-time wheat-fields pasturing for sheep, and fields running back to the moorland from which a century ago they were won; and, finally, there is the point of view of the scientist, comprehending most of the above, who draws deductions arising from a consideration of the climatic, geologic, and human influences on the one hand, and, on the other, of the numerous biological laws governing the growth, food, reproduction and dispersal of the ultimate units, the individual plants themselves.

Probably to a stranger it would seem next to impossible to disentangle the medley of plant-groupings which constitute the vegetation of a countryside. Still, in that somewhat difficult area, the West Riding, one can distinguish some fifteen groupings or associations, whose limits are generally well marked. Regarding, in the first place, the well-known moorlands, five types are seen: these are the bilberry summit, the cotton-grass moss, the heather moor, the grass heath, and the limestone hill-pasture. Woods are divisible also into five groups: coniferous, upland and lowland oak, ash-hazel copse, and beech. The areas of cultivation are the lowland wheat and the upland oats. In a few places a lowland swamp-vegetation is developed.

Most of the fifteen or so groupings can be recognised easily by the dominant plant; others by the circumstances and conditions of their positions. An example of the former is the heather moor, in which *Calluna* or ling is the predominant shrub. Under its shelter are many other species, such as bilberry, cross-leaved heath, cranberry, crowberry, mat-grass, bracken, &c. *Calluna* is termed the dominant plant; the others are sub-dominant. Examples of the groupings which are not represented with that comparative ease observed above are the wheat and oat areas. The farmland is subdivided into these two zones, wheat being taken as the indicator plant, following its general recognition as such in existing vegetation-maps on much smaller scales. The distribution does not depend on soils alone, and one must look more to climatic factors as determining its range; these are chiefly the average summer-temperature and annual rainfall. By actual observations of high-placed wheat-fields, investigation of parish-records, the cataloguing of arable weeds, and with the help of meteorological data, the limit of the wheat-area and oat-area has been fixed, though not with that accuracy possible with upland vegetation. In lowland districts, it seems as if whole counties must come under the designation of the wheat-type. This brings me to a chief point, which must not be lost sight of. The mapping of a large area is not the

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only end sought. In surveying any district, moorland, woodland, or wheatland, extensive notes are taken of the nature of the plant-associations and the various conditions under which they exist. In order that our conclusions may be sounder, excursions are taken at all times of the year. Notes taken in one district are compared with those taken in another, and similar one. Thus a general list of plants representative of the association or area is finally arrived at. In a similar way are built up the lists of plants for all associations, and information obtained concerning their biological conditions.

It will readily be seen that by our methods the plant-species inhabiting a district are arranged in the associations as they are actually found, and not, as is almost invariably the case in local floras, in the groupings of the Natural Orders. In certain ways this alternative point of view is very advantageous, alike to the beginner whom it is sought to interest in Nature study as to the maturer naturalist, who can find in the solution of œcological problems motive for endless study and enjoyment. There is a danger of thinking that the robbing a countryside of its rarest plants, to be carried home, dried, labelled, and buried in sheets of paper, is the beginning and end of botany. The present method puts no premium on this; the commoner plants are the most observed, and yet there is a place in our scheme for the rarest. By regarding the trees, shrubs, flowers, grasses, mosses, and moulds as individuals of one community, dependent in a variety of ways upon one another, rather than as items meet to be labelled and put into compartments, one is led to study the biology of the vegetable kingdom, to use the microscope, and through it to see visions of a thousand problems, some answered, many awaiting answer. And yet the systematic side of the science is not obscured.

The areas recently studied by us—the hill regions in Scotland and the heath of England—are especially suited for testing the scheme. They present all varieties of conditions, geologic and other. The results of the surveys are now published, and we wish that similar attempts may be made, either by societies or by individuals, to bring the whole country under a vegetation-survey. It may be started at any season of the year and on any area, no matter how small. A wood of a few acres, month by month, each square yard, each species of plant, can be studied with every degree of minuteness, and yet, to a true naturalist, without wasting a minute.

It would have been foolish on my part to have attempted more than a running glance at the investigation. The chief points can be grasped during a study of the published maps; if these are not sufficiently clear to the reader, an attempt on some new area within easy reach of his home will do more than anything else to clear up the idea.[1]

The Chairman: This is a communication eminently fitted for this Conference to discuss. It is just the kind of subject that Delegates should bring before their respective societies.

Mr. J. Hopkinson (Hertfordshire Natural History Society): It appears

[1] See *Smith, Robert* (1900), *Botanical Survey of Scotland.*

I. Edinburgh District. II. Northern Perthshire.

Smith, W. G., Moss, C. E., and Rankin, W. M. (1903), *Botanical Survey of England.*

I. Leeds and Halifax (Smith and Moss).
II. Skipton and Harrogate (Smith and Rankin).

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to me that it is not merely the compilation of the flora of a county that should be aimed at, but we should seek to get a general idea of its vegetation—which is a very different thing indeed. There are certain difficulties in mapping I should like to see discussed before the suggestions are put into print.

Mr. T. W. Woodhead (Huddersfield): This mapping system has come to stay, and I would suggest that the local societies commence on the 6-inch scale. There is, naturally, a difficulty in dealing with the 1-inch scale. The first difficulty of the beginner is to draw the line between the region of wheat and oats; but on the 6-inch scale the matter becomes simpler, and can be adopted by local botanists with much greater success. If a particular crop is growing in one field, it is easy to indicate it, and then, when once started, there is a fascination, which will be carried on from season to season, in building up the scheme definitely. This can be carried on in smaller areas on the 25-inch scale, and if local societies would devote their attention to this line of work they would find a renewed interest. The picture of the flora on this plan will appeal to us as it has never done before.

Mr. Ewing (Glasgow): I have listed eleven counties in the West of Scotland, and when we have considered all the plants found in a county we can fall back on listing them in this other way.

Professor Kendall (Yorkshire Geological Society): These two objects are not incompatible, but there has been so much list-making that in the minds of many people the collecting botanists are put on much the same level as the collector of postage-stamps or postcards. There are many extremely interesting problems to be solved. We cannot say how this will eventuate, or what important deductions may be drawn, but I can say this, I have seen Dr. Smith and his brother come down a mountain side with a botanical map, and, putting it alongside a geological map, the two are almost identical. That shows how one science assists the other. For example, there is a distinctive shape of a woodland—whether it is on the Millstone Grit, where deep and narrow gorges are cut, or in the Coal Measure country, where the rocks are not so durable, and where you have woodlands of a more expansive character. That is an illustration by the way, but I think such a survey as this will, among other benefits, tell us something of what is happening to our country from a climatic point of view. There is a remarkable fact, to which Dr. Smith has called attention—that our Pennine hills were once well wooded. In peats at heights of from 1,200 to 1,400 feet I have seen remains of large trees, but there are no trees growing there now. We want to know why these trees disappeared, and observations such as these may give us the answer, if not in this, in the next generation. Our children will thank us for it. It may be a climatic cause. What about reafforestation? We have thousands and thousands of acres of land available, and we have an unquestioned demand for timber. Can that demand be satisfied by any well-considered scheme of reafforestation? The answer must naturally come in a large measure from the botanist, and the man who works on these lines will be able to tell us why these forests disappeared. I should like to suggest another point of view, that of a sanitarian. We have committees on the investigation of town-atmospheres. What is the cause of the destruction of vegetation by town-smoke? In one district I found that if the evergreens in my garden were to bear out their characters, it was necessary to scrub the leaves so as to remove the soot. By the

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observation of this soot it would be possible for a botanist to make out something like a distribution of smoke. There is also the distribution of the lichens and mosses. I have suggested to the Yorkshire Naturalists' Union that we should have an advisory committee, selected from the different bodies—geologists, botanists, biologists, and so on—who should initiate or suggest lines of research in their different sections. Geologists have many questions which the zoologist and the botanist might answer, and this would be a sort of clearing-house, which would be of great advantage.

The Secretary then read the following note :—

Note on Maps of the Ordnance Survey. *By* T. V. HOLMES, *F.G.S.*

I enclose two pieces of the 6-inch-to-the-mile map of Kent, showing Greenwich Park, Blackheath, and a little of the adjoining country, which I have had in my possession twenty years or more. Also a much newer map, showing the same district[1] on the same scale. On the older map, in the gardens behind the houses which face Blackheath at its north-eastern end, are the words, 'Roman remains found here,' and the words 'Roman remains' appear in the adjacent part of Greenwich Park. A glance at the old map eastward of these spots reveals the fact that the line along which these Roman remains have been found points to their being on a westerly continuation of the Watling Street. And I may add that where the words 'Roman remains' appear in Greenwich Park there is a slight ridge, the direction of which is that of the words, and which is not traceable beyond them to the west.

On the newer map all this information about Roman remains is omitted. Such an omission might, of course, be almost or wholly unavoidable where an open space has become covered by houses since the earlier map was made. But in this case there has been no alteration whatever as regards the part in question. The omission is the more noticeable as, towards the south-western corner of Blackheath, '*Camp*, supposed remains of,' appears on the older map, and 'supposed *Roman* Camp' on the newer, at the same spot. In short, there is no sign of any desire to minimise archæological information pervading the newer map generally.

Possibly some of the Delegates may have met with omissions on the newer maps of their own districts.

The Chairman: It is a pity the Ordnance Survey should take off something from the old map. There are, undoubtedly, Roman remains in Greenwich Park, and it is to be regretted that the reference to them should have been omitted from the new map. I think we should write to the Ordnance Survey and call attention to the omission. The more common defect is to put down 'Roman remains' where none ever existed. I have had to ask them to remove the reference in a Gloucestershire map; but in this case there is little doubt that the old map is correct. There is a row of some twenty houses in the gardens of which Roman remains might be found at any time, and it is rather hard on the owners or tenants, who have not had their attention called to it. Besides that, the engraving is not nearly so well done as in the old map.

[1] London: Sheet 12, N.W. Edition of 1894–96.

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It was resolved that an application should be made to the Committee of Recommendations, asking for the reappointment of the Corresponding Societies Committee, with a grant of 25*l.*

Second Conference, September 15.

Mr. W. Whitaker, F.R.S., in the chair, followed by Rev. J. O. Bevan, M.A.

The Chairman: Before proceeding to deal with the agenda I would like to say a few words on a conversation I had with the President of the Association yesterday. He asked me how I thought the Conference would take the suggestion he had laid before the meeting last Thursday. I said I had not had an opportunity of discussing it privately with any of the members, but judging from the discussion in the Conference I thought they were very much disposed to take it up. He said, if anything is done, it should be done quickly. He believes there is or may be a rival organisation in the field, so that it would be distinctly best to strike while the iron is hot. I would ask you to bring the matter which Sir Norman Lockyer introduced to us before your Societies at the first convenient opportunity, and get them to act if they can.

The Rev. T. R. R. Stebbing asked for more definite information as to what was required of the local Societies.

The Rev. R. Ashington Bullen said he was not quite clear as to what was intended, and he asked whether it was a question of forming a Guild of Science or of capturing votes.

The Chairman: Both; and certainly the appointment of an acting committee which would be ready to take up any questions referred to it without any delay. I think that would be rather an important matter.

The Secretary then read the following paper:—

A Suggestion with respect to Exploration and Registration Work for County Local Societies. *By* WILLIAM COLE, *F.L.S., Hon. Sec. Essex Field Club.*

Having been Secretary to a registered local scientific Society during the whole period of the life of the Corresponding Societies Committee of the British Association, I have been impressed with the number and variety of the subjects recommended to the attention of local Societies by the Committee from year to year. I have also been struck with the lack of practicability of many of these recommendations from my point of view—that is, of one having the success and progress of his Society at heart. Such matters as the 'Collection of Statistics concerning Trained Chemists employed in English Chemical Industries'; investigations concerning 'The Resistance of Road Vehicles to Traction,' or the 'Consideration of means by which better practical effect can be given to the Introduction of the Screw Gauge proposed by the Association in 1884,' and the like, although subjects of professional importance, are but little adapted to enlist the co-operation of a body of amateur biologists, geologists, and archæologists. It seems to me that the subjects most likely to prove attractive to the members of the greater number of our local Societies are those connected with such branches of science as are within the opportunities and abilities of amateur observers, and which at the same time

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are such as will arouse the enthusiasm and 'county-patriotism' of the supporters of the Societies. It is difficult at all times to obtain a sufficient number of members to permit of the carrying out of the necessary work of the Societies (meetings, publication, &c.), and it is still more arduous to collect funds for any piece of work supplemental to the routine business. I suggest that local Societies will best aid in their humble way the progress of science by confining their energies to the acknowledged three main objects of their existence—the minute study of the natural history and archæology of the counties; in educational work of a propagandist character; and in assisting in the formation of well-planned local museums and scientific libraries in their own districts.

All holding similar views will cordially approve of such pieces of work as the photographic survey of a county, or of the botanical survey advocated in a paper placed upon the agenda at the present meeting. And to be welcomed is the project for the preparation of a map-index to prehistoric remains, so ably advocated by Mr. C. H. Read, F.S.A., at the Belfast meeting of this Committee. I should like to expatiate briefly upon these ideas, and, as I have no authority to speak for other counties, I will confine my remarks to Essex.

In Essex considerable changes in the flora and fauna may be anticipated in consequence of rapid extension of building, the cutting down of woods and hedges, alterations on the coast brought about by the draining and cultivation of salt marshes and the silting up of estuaries, &c. Dr. Sorby has described the changes in the shallow-water fauna of the coast during the last fourteen or sixteen years. Inland and near the towns, the destruction of raptorial birds and mammalia by gamekeepers, and the increase of insectivorous birds consequent upon the enforcement of the Wild Birds Acts, are causes which apparently determine the disappearance of many insects and mollusca which is so regrettable. These are strong reasons for the preparation of more detailed floral and faunal catalogues than any yet produced, of the character which I understand Dr. Smith and Mr. Rankin will advocate in their paper. If such work is not done soon it will be too late, as the rapid changes of environment and food will exterminate some species and modify the habits of others. And I would emphasise the importance of our local museums being furnished with extensive and accurately localised sets of plants, animals and fossils before destructive influences have blotted out for ever many rare forms and variations. The sea has washed away a great part of our fragment of Waltonian Crag, and the builder has covered up or carted away our river-terraces and brick-earth deposits.

This scientific collecting and registration, if done systematically and thoroughly, will need not only much careful work, but also the expenditure of considerable sums of money.

The desirability of carefully registering and systematically exploring the prehistoric remains in Essex has engaged our attention for many years past. As long ago as 1883 our Vice-President, Professor Meldola, F.R.S., read a paper before this Conference on 'Local Societies and the Minor Prehistoric Remains of Britain.' The paper was printed *in extenso* in the 'Transactions of the Essex Field Club,' vol. iv. pp. 116–122. The destruction of some of these remains, and the precarious tenure of existence of such as remain, have often been the subject of remark, as in the noteworthy address of Mr. Read referred to above. I am very glad to say that the suggestions of these gentlemen with regard to cataloguing

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and mapping these interesting relics is now being carried out in Essex. Our Vice-President, Mr. Chalkley Gould, has prepared for the first volume of the 'Victoria History of Essex' a very complete list of them, accompanied by a map. But a catalogue, however excellent, is only a preliminary step. Accurate plotting down, on large-scale plans, of the outlines, geographical positions and elevation of these works, and their careful scientific exploration, so as to determine their probable periods and motives, still remain to be undertaken. I venture to submit that this is work which must be done by local Societies if it is to be done at all. Great London associations may undertake the 'reconstruction' of Silchester; a fortunate county may possess a Pitt-Rivers to plan and munificently carry out archæological explorations; we may find the study of the physical and life conditions of the North Sea becoming a matter of Government and international importance. But the patient tasks of collecting and registering plants, animals and fossils, and the examination of minor earthworks, camps, red-hills, deneholes, &c., should be the duty and pleasure of local enthusiasts.

The councils and officers of many of our local Societies hardly need committees of the British Association to indicate these lines of activity. They have been fully alive to them ever since their Societies were called into existence. But, as we in the Essex Field Club know full well, such work is very costly, and in most cases quite in excess of the slender balances at our bankers. We have the will, but we lack the means. And this is the position with very many of our local Societies.

Is there any escape from this difficulty? I think it can be shown that there is a way out.

Everyone knows that our county councils have very considerable annual sums entrusted to them for purposes summed up in the very elastic phrase 'technical instruction.' This is in addition to any rate for primary or secondary education. The allocation of this technical education money is in the hands of the councils, subject to some sort of revision by the Board of Education. The annual income from this source in Essex is considerably over 20,000*l*.

My proposal is that the county council of each county in which a recognised scientific Society exists should be asked to allocate a small annual sum (say from 100*l*. to 200*l*.) for the purposes alluded to, in accordance with some such scheme as the following:—

1. That the local Society should in each year lay before the education committee of the county council proposals and plans for any explorations or investigations which, in the opinion of the expert committee of the Society, are worthy of being undertaken, and that on approval the estimated sum required for the work and for the publication of the report be allocated to the Society.

2. The committee of the Society having accomplished the work, should prepare a detailed report, with such maps and illustrations as may be necessary. This report might be printed in the journal of the Society, copies being struck off for sale. Or the reports might be issued on a uniform plan for the whole kingdom. In any case the reports should be issued at a very cheap rate for distribution to the public.

3. Any sum unexpended might be returned to the council, or carried to the next year's work.

4. In selecting the subjects proper for such a series of investigations

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the peculiar conditions and requirements of each county will be considered. Taking Essex as an example, the following may be suggested :—

(*a*) The accurate surveying and plotting down on large-scale plans of typical prehistoric remains, particularly of such as may be in danger of destruction, and the careful exploration of the same under expert direction.

(*b*) The preparation of accurate lists and of maps of the county, showing the positions and mode of occurrence of any relics of prehistoric age hitherto found therein, with indications of the museums or collections in which they are preserved, and references to any published details and figures.

(*c*) Exploration work in the shallow-water districts of the North Sea and in our estuaries and rivers, so as to collect materials for full and accurate lists of the marine and fresh-water fauna and flora, and to study the conditions regulating the occurrence of each form where possible.

(*d*) The mapping out of the distribution of inland plants and animals, having like regard to the conditions of their occurrence ; the study of the varying conditions of agriculture and gardening in different parts of the county.

(*e*) The exploration of interesting geological deposits, so as to accumulate, before they disappear, as perfect sets as possible of characteristic fossils. Examples : our Walton Crag, brick-earths and terrace gravels.

(*f*) The study and registration on large-scale maps of coast erosion and the formation of sandbanks and the silting up of our estuaries.

(*g*) Any special investigations which may be suggested by the county council itself, or by the British Association Committee.

5. All specimens, plans, &c., thus obtained or made should be deposited in the county museum, the museum authorities undertaking to suitably preserve and register them for future study.

6. As above indicated, all the reports should be published at a cheap rate, and copies deposited in local libraries and in the principal public libraries in the kingdom. The British Association might well be asked to catalogue these reports from the several counties as an Appendix to the Report of the Local Societies Committee.

Such is a rough sketch of my proposal. I have assumed that a county scientific Society exists in each county. Where this is not the case, a joint committee of the smaller Societies of the county might be formed for this business. I may be permitted to observe that, in my humble opinion, it is most desirable that such Societies should at once unite to form strong county units. Each county should have *one* scientific Society and *one* archæological Association, with local sub-committees, if thought necessary.

I have left the primary difficulties until the last. Would our county councils consider the subjects mentioned and the suggested method of treating them of educational value ? If so, would they assist ? and, finally, Is such an allocation of educational funds legal ?

I submit that the small annual sum mentioned would, if expended in this way, produce results of considerable educational value. We spend vast sums in teaching modern history, and ought we to consider the 'buried history of Britain' (as it has been happily termed) of no importance ? The work of collecting information respecting plants, animals,

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fossils, encouraged and directed by the local committees, would certainly be of direct educational value to all taking part in it; and the reports, when issued, would be admirable object-lessons, serving to show how much of interest our own counties possess. And now that the importance of museums in education is recognised by scores of thoughtful writers and speakers, would not the sets of specimens, accurately named, localised and described, be of real use to students and investigators? Of the scientific importance of the results from the work advocated it is unnecessary to speak before this Committee. And we must not forget that there is a strong feeling of local patriotism, which appeals to all, scientific or others.

Of the legal aspect of the question I am not qualified to speak; the problem might be submitted in the first instance to the Board of Education. Should it be found that the present law would not permit of such allocation of funds, it might not be difficult to induce the Government to introduce a two-line clause into some 'omnibus' Educational Bill (there are sure to be a few in the near future) permitting the county councils to act as indicated above.

I would suggest, if the proposals meet with the approval of the Scientific Societies Committee, that a small sub-committee be appointed, to meet in London and consider the steps that may be necessary to bring the matter before the public and the authorities. Perhaps the British Association itself would aid in bringing the matter prominently before those in authority and the public generally, and it might not be difficult to enlist the sympathies and co-operation of a few Members of Parliament favourable to scientific education, supposing any parliamentary action is necessary.

I should like to see some active, practical steps taken; in my opinion, the local Scientific Societies Committee could not confer a greater benefit on the Societies, nor aid more the progress and study of natural science and archæology in the counties by the numerous amateurs now existing than in promoting some such scheme as that I have advocated.

The Chairman (Rev. J. O. Bevan): Mr. Cole's paper is now open for discussion, and there are many points of importance suggested by it which will, no doubt, receive your consideration.

Dr. W. R. Scott (Delegate from Section F): I feel considerable diffidence in saying anything on this subject, because I am afraid in this meeting I am somewhat of an outlander, representing as I do the Economic Section. But I would like to recommend to the consideration of the members of the Committee the work indicated in the paper in one direction particularly arising out of my own personal experience. One of the subjects of economical investigation which is going to come most prominently before the public in the near future is that of economic history, and in the investigations in connection with this I had occasion to examine the records of local societies with reference to a question of considerable practical and theoretical importance, viz., the localisation of industry, finding out how certain industries sprang up or died out in certain places. In compiling information of the kind indicated under the head of archæology, I am certain investigators will come across records of old industries and callings, and things of that nature, which are frequently passed over. I should like to suggest to those who are engaged in the study of economics, that if they would make a note of these things it would be of very great assistance to us.

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Mr. W. F. Stanley (Croydon): In our local Society we have two subjects which seem to be very appropriate, at least for such Societies, and one of them would aid very materially what Mr. Cole has put before us. Photography is very popular with our Society. The observations we record by means of drawings are often very poor, but we can record them correctly by means of photography in much less time. Another thing which is very popular with these Societies is meteorology. There are many elderly people to whom it is a source of pleasant occupation to make daily observations of meteorological conditions. I would mention, with regard to the polytechnics, in which I take a very great interest that the Government money is suggested to be for technical education, and it is really so applied in many instances. But the money is so thoroughly taken up and so usefully employed in that direction that I think there would scarcely be any to spare for a learned society in which knowledge is the sole aim. It is generally technical knowledge that is required—knowledge which will be of value to students in life, and will greatly aid in elevating the classes for which it was originally intended.

The Hon. Rollo Russell (Haslemere): I was going to suggest before the previous Delegate spoke that possibly meteorology might be added to the subjects mentioned in the paper; and though this might not come within the view of many Societies, observations might be made of the diseases of plants, and of the relations of plants to meteorology. Meteorology furnishes an enormous field for investigation, and if this were added to the subjects mentioned it would help towards getting grants from county councils and town councils. Experiments might be made on plant-life in relation to soils, weather, and various other conditions.

Professor Weiss (Owens College, Manchester, Delegate from Section K): I am rather sceptical of getting a grant from the county council for the purposes suggested in the paper. I think aid would come better from the British Association grants, which I am sorry to say are decreasing, while the demands are increasing considerably. I doubt very much whether we are getting further forward by resting our hope on the county council, but I do not see why we should not make a trial. It might be useful, though I doubt whether all county councils will have it in their power to give grants. Section K might bring this up in connection with the registration of botanical photographs. A pamphlet will be sent to each Society giving particulars about photography. We are very desirous of getting records of plant-life, both as regards the natural plants which we find in different parts of England, and also in regard to the acclimatised plants. For example, there are districts in the south of England where we have tropical plants grown under favourable conditions, and it is worth recording by photographs. Then, as to plant diseases, we are desirous of getting photographs of these, when we have crops destroyed, as we have had to deplore from time to time. It would be necessary and desirable to have records from different districts recording statements which can be referred to afterwards. Then curiously injured trees, trees injured by lightning, wind, or other causes, trees of great age or possessing other peculiarities, are well worth putting on the records of each district, and should secure the attention of local Societies. It is only by getting local Societies interested and taking up this work that we can hope to obtain a series of records such as we should get in this country. I am glad that several Societies have already undertaken this work for the coming season.

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Dr. Herbertson (Delegate from Section E): I should like to emphasise the necessity of putting on the maps as many observations as possible. Cartographers feel the necessity for having data put in a more convenient form than is done in tabular schemes. One of the first duties of local Societies should be to undertake a map of the district of all objects of study, whether fossils or plants. A great advance has been made in botanical mapping by the adoption of the morphological or physiological classification and in other ways. It is found that this applies not merely to botanical specimens, but also to the geological phenomena and to economical phenomena. I was glad to hear Dr. Scott insist on the necessity for observing the distribution of local industries, and I would suggest that the distribution in space be considered as well as the distribution in time. The value of any description by local Societies is to express the data on the map as well as in tabular form, and to aid in the interpretation of them, for that is the object of the study of distribution. The Societies would find great assistance by having a geographer on their committees.

Mr. W. Ackroyd (Halifax Scientific Society): As to our Society, its work has a direct bearing on this subject. We have a bi-monthly publication, which has been carried on at a very slight loss for something like ten years, and no doubt will be carried on for a number of years further; for, on account of the interest of the subjects with which it deals, it will command a wider circulation. The subjects dealt with are similar to those mentioned in the paper this afternoon. The geologists have been interested in the well-sinking in the neighbourhood, and through the kindness of the gentlemen who have sunk these wells they have been able to take the cores in succession and make up vertical sections, forming a valuable record. Another subject has been afforestation; and here the Society has been of very great use to the corporation, which has consequently planted trees around their reservoirs, and no doubt this work will be increased. With regard to funds, I do not think any corporation where there are Labour members, Conservatives, and Liberals fighting against each other will permit anything illegal to be done; but we have got funds for certain lines of work. We have two museums—one at Bankfield given up to anthropological subjects, and another at the other end of the town given up to geology and mineralogy mainly, and for these museums honorary curators are appointed from the local scientific Societies. When funds are required they put down the amount wanted and the purpose for which it is required, and a representative of these curators goes before the committee of the council and makes a recommendation. So far we have been able to get all the money we have wanted. The grants made from time to time have been from 100*l.* to 200*l.*, and even as much as 300*l.* at a time. I do not know exactly why it becomes legal for this money to be advanced to us, but I think it is under the Free Libraries Act. Here is the paragraph in the 'Year-book' relating to the Technical Instruction and Public Library Committee, and it is under one of these Acts that the money I allude to is granted: 'The duty of the committee is to manage the free libraries and museums, and to carry into effect the provisions of the Free Libraries Act, the Gymnasiums and Museums Act of 1891, the Libraries Act Amendment Acts of 1891 and 1898, and the Halifax Corporation Act of 1898 relating to the library rate.' I have no doubt that what we do in Halifax, Delegates will in time be able to do in other places.

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The Chairman: I should like to say it is the desire of the Corresponding Societies Committee to take the general sense of the Conference on this subject. There is no doubt that the proposal made by Mr. Cole is a very important one, but it requires to be worked out, and worked out with far greater detail than I think is possible in the present discussion. It would be necessary, in the first place, to know the limits of the county councils, for these do not cover the whole of the county, seeing that the county includes County Boroughs. Then the funds required would have to be considered. The Government's money, the 'whisky money,' might be devoted to purposes not strictly educational, and we should also want to know the way in which the boundaries of the local Societies would be involved. If the principle meets with the approval of the Conference, it might be thought well to refer the whole matter to the Committee, which would consider it in London and take into account all those matters which have been suggested this afternoon. Of course we are quite in the hands of the Delegates, and are prepared to welcome any other suggestion; but, speaking on behalf of the Committee, they will be glad to take your acceptance of the principle for granted, and enter into as full a consideration of the details of the matter as may be possible.

Replying to Principal Griffiths, who asked what was meant by the principle of the matter, the Chairman said: The principle that the work should be undertaken, and that the ways and means should be afterwards considered—that we thought the work was a necessary work. That seems to be the important thing to get hold of. Other things would have to be dealt with by independent investigation.

Mr. J. Hopkinson (Hertfordshire): Allow me to give you the experience of the Hertfordshire Society on the question of museums. We endeavoured to establish a museum in connection with the Society, but could not do so for want of funds. Several members of the Society approached the county council, Sir John Evans especially. We got up a public meeting, and then collected sufficient funds to build a small museum. Lord Spencer gave us the land, and the museum is managed by a board of honorary curators, with one for each department. The whole of the grant that we are able to get from the county council, although we have very considerable influence there, seeing that many of its members are members of our Society and that we have the enthusiastic support of Sir John Evans, has been 300*l.* for the building fund, and 115*l.* per annum towards the expenses of the museum, on the condition that we give free lectures on such technical subjects as come within the scope of the powers for which they can devote this money. We have to subscribe towards the keeping up of the museum. As to the maps, no doubt they are very useful, as it enables you to see things at a glance; but I presume all these investigations are not of very much use unless they are published, and it is a very much more expensive thing to publish maps than to publish tabular statements. We, like other Societies, I suppose, frequently overdraw our banking account, and it is with the greatest difficulty that we keep up our Society owing to the want of funds.

On the motion of the Hon. Rollo Russell, seconded by Mr. Stanley, and supported by Principal Griffiths, the suggestions made by Mr. Cole were referred to the Corresponding Societies Committee.

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Railway Fares for Members of Scientific Societies.

The Secretary read the following letter from Mr. Herbert Stone, F.L.S., F.R.C.I., President of the Birmingham Natural History and Philosophical Society, and Delegate to the meeting :—

With the assistance of my colleague, Mr. Richard Hancock, I have recently been engaged in getting up a petition to the great railway companies, on behalf of the scientific and photographic Societies of the Midlands, asking for the same privileges as are enjoyed by anglers, namely, the 'picnic' rate, or fare and a quarter, to certain specified places upon presentation of the Association ticket at the booking-office. The joint committee formed for the purpose of gaining this end, and of which Mr. Hancock and I are joint Secretaries, represents twenty-two Societies, with a membership of 1,700. Our petition has met with a refusal, after being before the periodical meetings of the managers of the various railway companies. At these meetings all questions affecting railways in general are discussed, and amongst more important matters a petition such as ours would naturally get scant attention, and I doubt if the meeting was put in possession of the arguments for our side as set forth in our letter.

My object is to ask if the British Association can aid us. An application from the Association would at least be considered, whereas the curtness of the replies to our petition shows that the companies consider that we are a negligible quantity.

Of course it would be unreasonable to suppose that the Association would act for a limited body of Societies, but I imagine from the support given to the project from those already organised that it would not be difficult to obtain the assistance of the whole of the Societies of the same nature in Great Britain. In this work I should be pleased to take my share.

Copy of Letter referred to.

Bracebridge Street, Birmingham:
June 23, 1903.

The Superintendent of the Line,
—— Railway.

Sir,—On behalf of the Societies enumerated below, for whom we are authorised to speak, we take the liberty of asking if you can see your way to grant to the members of those Societies the 'picnic' arrangement as at present enjoyed by the Birmingham and District United Angling Association. We wish to point out that naturalists and amateur photographers work singly, and not in bodies, and that the ordinary method of arranging for parties of ten rather discourages excursions amongst this class than otherwise. The privilege of booking at a fare and a quarter to the stations at present set out on the anglers' cards would, we are confident, result in a large increase of traffic both in point of number of excursions and of distance travelled. In 1884, when the anglers' societies were federated, their membership was about 300. At the present time it is many thousands. It is fair to assume that angling *per se* would never have produced such numbers without the stimulus of the reduced rate, and we believe that a similar increase would take place in the traffic if the same concession be made to our own body, as the localities near at

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hand are for the most part worked out, and our members are in need of a larger field for their energies.

We beg you to take into consideration the fact that every naturalist or photographer who visits a place on your line becomes an advertising agent for that place, and we venture to say that, in view of innumerable addresses, lectures, exhibitions of specimens, photographs and lantern-slides, there is no better medium of advertisement for your line than the body which we represent.

We can assure you that this concession would not be abused in any way. One of the Societies affiliated with us, the Longton and District Photographic Society, which already enjoys the concession we now ask for from the North Staffordshire Railway Company, has never heard of any attempt whatever on the part of any of its members to use the privilege for any other purpose than that for which it was granted.

We are, Sir, yours very truly,

(Signed) HERBERT STONE,
RICHARD HANCOCK,
Hon. Secs. to the Committee.

(Here followed list of Societies.)

Mr. Hopkinson: There is only one Society that I know which has been able to get this privilege from the railway companies, and that is the Yorkshire Naturalists' Union. Any member can join any of the excursions of the Association on reduced fares by simply producing his card of membership, on which his name is signed, and the excursion circular. The card is issued on the payment of the subscription. I do not think that any other Society has succeeded in doing this. Our Hertfordshire Society has tried, but we must have at least ten members to enable us to get a joint-ticket; but if the railway companies were approached by an official body representing the whole of the Natural History Societies of the country, we might get for them what the Yorkshire Union has done.

Mr. W. Parkin and Mr. Lamplugh pointed out that the privilege had been modified.

Dr. W. R. Scott: As to the Irish Societies, I may point out, as a member of the largest of them, the Royal Society of Antiquaries of Ireland, that they get tickets at practically single fares; at all events it is not more than a fare and a quarter, and the procedure is this: Any member wishing to attend an excursion must, within ten days of the excursion, get a form from the secretary of his Society; it is presented to the railway company, and the secretary then gets the ticket at reduced rates.

Mr. G. W. Lamplugh: I was going to raise a point as to the Irish railways, as it shows an advance on anything in England. Not only does this privilege extend to the excursions, but to any work carried on by a field club. On two occasions, when I have gone across to see excavations in the West of Ireland, the Secretary had it in his power to give me a warrant authorising me to get a ticket for field-club business at single fare for the double journey. If this privilege can be wrested from the English railways it will be a great advantage.

Captain Dubois Phillips, R.N.: Golf-tickets are made out in exactly the same way. You get your ticket from the secretary, sign it at the bottom, and carry out the same routine. I do not think it would be difficult to get if we were all to come together.

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Reports of Delegates from the Sections.

The Chairman : The next thing is to hear the Delegate from Section A, who will give us an idea of what is suggested by his committees.

No response was made, however, nor to the call for the Delegate from Section B ; but the Secretary of the Conference read the following communication from Mr. W. Marriott, Assistant Secretary of the Royal Meteorological Society :—

I should be glad if you would bring to the notice of the Conference of Delegates of Corresponding Societies the fact that the Council of the Royal Meteorological Society have undertaken to furnish for the 'International Catalogue of Scientific Literature' the titles of papers bearing on meteorology which are published in the British Isles.

As this work cannot be complete unless the Society is in possession of all the publications containing meteorological papers, the Council would be glad if the Delegates of Corresponding Societies would assist them in this matter, by requesting all the local scientific Societies printing papers or reports bearing on meteorological subjects to forward a copy of the same to the Royal Meteorological Society, 70 Victoria Street, Westminster, S.W. (if they do not already do so), to insure the titles being included in the 'International Catalogue of Scientific Literature.'

Section C, Geology.

Mr. Lamplugh said : The Section has several Committees at work, and is being greatly aided by the local Societies. The first is the Section for the registration of geological photographs. The second Committee is that on the registration of erratic blocks, and there the local Societies send in their reports to the central Committee. In printing the reports of the Committee the Societies are mentioned, together with the amount of work each has done towards the common object. The exploration of the Irish caves is being carried on under the auspices of the local Societies in the same way. Recent explorations at Kirmington, in the East Riding of Yorkshire, were originated by the Hull Societies. In all these cases the aid of the local Societies has been very great towards the work of the Section. The work of the Triassic Committee is proceeding on similar lines, and, in fact, in all the Committees of Section C the idea is to get local Societies to aid in the work of the central Committees.

Section D, Zoology.

The Rev. T. R. R. Stebbing said : I may mention, with regard to this Section, that the Committee hope when next year the Association meets in Cambridge a great effort may be made for the organisation of zoological science and zoologists in general, and perhaps our Delegates will bear that in mind, and if they have any contribution to offer it will be very useful. I have an axe of my own to grind, because for some years past I have been the Committee appointed, through the kindness of the Conference of Delegates, for the investigation of the underground fauna of Great Britain. The subject of well-boring has been already alluded to by Mr. Ackroyd. Well-shrimps can only be got by well, or at least continually boring you and other Associations on this subject. In my own neighbourhood I had to work for some years before I could

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get hold of these well-shrimps. At length I got a supply, some from various parts of the country through my own pupils, and some from a working man close by. I happened to give a lecture which this man attended, and next day he brought me a supply from the bottom of his well. They are little creatures, transparent, with several legs, and from half to a quarter of an inch in length, according to the species. They are rarely found, and yet people in many parts of England say they are very common. It is difficult to persuade people that they are worth collecting. On the Continent they have several species, and in England we may have more of these interesting fresh-water crustaceans than are yet known. Unless the Delegates will help me it is next to impossible to make a report as a Committee. These little creatures are most commonly found when the well is tolerably empty. They live at the bottom, and have feeble swimming powers. Well-owners generally keep their presence dark, because they are afraid the sanitary inspector will come and declare the water impure. As a matter of fact, these creatures are a testimony to the purity of the water, so that I hope you will not think a record of them any injury to the reputation of the well. Specimens in methylated or other spirit or in formalin, addressed to Ephraim Lodge, The Common, Tunbridge Wells, will be very acceptable. In every case the place of capture should be specified.

Section K, Botany.

Professor Weiss, speaking on behalf of the Botanical Section, said: This Committee is being greatly aided by local Societies. The Committee wishes to draw attention to two other pieces of work in which they might assist. The first is that the Committee has appointed Mr. Alfred Friar to prepare a monograph on the species of the British *Potamogeton*. Then, Miss Sargant has asked me to mention that she is investigating the British Orchids, as to which she would like to have some suggestions and assistance.

Miss Sargant (Holmesdale Natural History Club): The points are in relation to plants with underground growth. In the case of the orchids, people regard them for their flowers, which are open for only three or four weeks; naturalists tell us that the leaves die about the same time, but I fancy they may last longer. Further, are the plants reproduced to any extent by seed? I shall be glad if natural history Societies can give me any assistance on the following specific points:—

1. Particulars as to the length of time in the year during which the *leaves* of any native orchid are above ground. [The leaves are commonly so inconspicuous that they escape notice out of the flowering season.]

2. Information as to the reproduction of such species by means of seed under natural conditions.

(*a*) What species produce seed freely or at all?

(*b*) In the case of each species examined, are seedlings found in the neighbourhood of the parent plants, and do they seem to survive the first winter?

(*c*) In the case of young plants—that is, those which have not flowered—can those which have grown from seed be easily distinguished from vegetative shoots, when such occur?

(*d*) In general, what proportion of the young plants in each species are seedlings?

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Of course I should like the information to be obtained, as far as possible, without rooting up the clumps, which is rather like killing the goose which lays the golden eggs. I should be glad of drawings of germinating seeds.

Section E, Geography.

The Secretary of the Conference read the following list of subjects for research in connection with local geography, which he had received from Mr. E. Heawood, M.A., the Recorder of the Section :—

Correlation of Physical Surface Features with Geological Structure.
Evolution of River Systems.
Relation of Physical Factors to Distribution of Population.
Distribution of Vegetation, and the Relation of Plant-formations to their Environment.
The Distribution of Zoological Groups in Connection with Environment.

The study of representative types of *Insecta* and *Mollusca* from this point of view is specially recommended by biologists, but it may be made equally interesting from the point of view of geography.

American Handbook of Learned Societies.

Mr. J. David Thompson, who had just arrived in England from Washington, made the following remarks : I want briefly to say that the Carnegie Institute founded in the city of Washington, D.C., U.S.A., has recently allotted a sum of money to prepare a comprehensive 'Handbook on the Learned Societies of the World.' I have been appointed editor, and have sent out circulars and leaflets to the secretaries of the societies included in the British Year-book. The historical, literary, and archæological are included with the scientific, and as these circulars were sent out only two weeks ago, they would arrive during the meetings of this Association, so that the secretaries will find them when they return home. I want to ask you to favour us with accurate replies to these circulars as soon as you are able to do so. This will be a rather important and useful handbook to all of you, particularly in relation to the foreign societies with which you may wish to exchange publications ; and perhaps very many have discovered already that it is rather difficult to get into communication with some of them ; and I suppose they find the same difficulty.

There is a British 'Year-book' which is a current handbook, but only describes the publications of the current year, and we wish to give a complete geographical statement of our societies, and of those who are in the position of secretaries, delegates, and other officials. I would esteem it a favour if you would ask your secretaries when you return home to kindly look into this matter carefully.

The following is an outline of information desired for use in the preparation of the 'Handbook to Learned Societies' :—

1. *Name.*—Official name at the present time.
2. *Address.*—Postal address of the society, and the name of the permanent official (if any) to whom communications should be addressed.

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3. *History.*—Brief historical note, giving date of foundation or incorporation, changes of name or organisation (*e.g.*, fusion with other societies), with bibliographical references to sources of fuller information.
4. *Meetings.*—Time and place.
5. *Membership.*—Number of members (active, honorary, corresponding, &c.), with the fees paid by each class.
6. *Publications.*—A. *Serial.* The exact title of each serial publication issued by the Society since its foundation, giving for each series of such publications change of title (if any), number of volumes (or brochures), period covered, place and dates of publication, size and frequency of publication.

E.g. 'Proceedings,' v. 1–12 (1897–1902), London, 1898–1903. 8vo, half-yearly.

B. *Special.*—If a printed list exists, kindly refer to it, and send a copy if one can be spared.
C. *Distribution.*—(i.) Conditions of exchange; (ii.) prices and place of sale.

7. *Research Funds and Prizes.*—Brief statement indicating field covered, amount and conditions of grants in aid of research, and conditions of competition in the case of prizes.

The information should be addressed to: '"Handbook to Learned Societies," c/o Library of Congress, Washington, D.C., U.S.A.'

On the motion of the Rev. T. R. R. Stebbing, seconded by Mr. Stanley, a vote of thanks was tendered to the Chairman, the Vice-Chairman, and the Secretary, and the proceedings terminated.

Addenda.

At a meeting of the Corresponding Societies Committee held on November 9, 1903, the following Resolution which the Rev. E. P. Knubley was desirous of moving at the Southport Conference, but was unable to move through inability to be present at the second meeting, received consideration:—

'That the members of the Corresponding Societies be requested to give as much help as they can to teachers in those Elementary and Secondary Schools which are taking up the subject of Nature Study.'

This Resolution was carried, and it was resolved to recommend it to the favourable consideration of the various Corresponding Societies, leaving the exact form in which assistance could be rendered for future discussion.

At the same meeting Mr. W. Coles's paper was discussed, and the following Resolution was carried:—

'That the Corresponding Societies be recommended to enter upon the 6-inch Ordnance maps any unrecorded natural features and archæological remains.'

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The Corresponding Societies of the British Association for 1903–1904.

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204 George Street, Glasgow. R. Barnett Johnstone and T. Nisbet	245	None	2*s.* 6*d.*	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. .	J. Langfield Ward, Royal Literary and Scientific Institution, Bath	100	5*s.*	10*s.*	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	243	None	1*l.* 1*s.*	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Belfast Nat. F. C. .	Museum, College Square. R. Patterson and N. H. Foster	350	5*s.*	5*s.*	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Berwicksh. Nat. Club .	Rev. J. J. M. L. Aiken, B.D., Manse of Ayton, Berwickshire	400	None	10*s.*	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birm. and Midland Inst., Paradise Street, Birmingham	140	None	1*l.* 6*s.*	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc..	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall and W. B. Grove, M.A.	172	None	1*l.* 1*s.*	Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	J. C. Clark, 9 Marlborough Place, Brighton	170	10*s.*	10*s.*	Report, annually.
Bristol Naturalists' Society, 1862 .	Bristol Nat. Soc. . .	S. H. Reynolds, M.A., University College, Bristol	152	5*s.*	10*s.*	Proceedings, annually.
Buchan Field Club, 1887 . . .	Buchan F. C. . .	J. F. Tocher, F.I.C., 5 Chapel Street, Peterhead	170	1*s.*	5*s.*	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	B. L. Oswell, 5 Balmoral Road, Burton-on-Trent	210	None	5*s.*	Annual Report. Transactions occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C. .	H. E. Forrest, 37 Castle Street, Shrewsbury	168	5*s.*	5*s.*	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867 .	Cardiff Nat. Soc. . .	Wm. Sheen, M.Sc., 2 St. Andrew's Crescent, Cardiff	470	None	15*s.*	Transactions, annually.
Chester Society of Natural Science, Literature, and Art, 1871	Chester Soc. Nat. Sci. .	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard	977	None	5*s.*	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. .	The Museum, Public Buildings, Penzance. John B. Cornish	96	None	1*l.* 1*s.*	Report and Transactions, annually.
Croydon Natural History and Scientific Society, 1870	Croydon M. N. H. C. .	Public Hall, Croydon. G. W. Moore	220	None	10*s.*	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C. .	Dr. H. C. March, Portesham, Dorchester	333	10*s.*	10*s.*	Proceedings, annually.
Dublin Naturalists' Field Club, 1885	Dublin N. F. C. . .	G. H. Pethybridge, Ph.D., and J. de W. Huish, Royal College of Science, Dublin	150	5*s.* Assoc. 2*s.* 6*d.*	5*s.* Associate 2*s.* 6*d.*	'Irish Naturalist,' monthly; Report, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc. .	A. Lander, The Medical Hall, Canterbury	102	None	10*s.*	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N. H. Soc. .	Dr. H. Habgood, Stafford House, Upperton Road, Eastbourne	100	2*s.* 6*d.*	7*s.* 6*d.*	Transactions, annually.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc. . .	India Buildings, Edinburgh. James Currie, M.A., F.R.S.E.	250	10*s.* 6*d.*	12*s.* 6*d.*	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association	Elgin Lit. Sci. Assoc. .	R. B. Gordon, Elgin	98	None	5*s.*	Transactions, occasionally.
Essex Field Club, 1880 . . .	Essex F. C. . . .	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex	300	None	15*s.*	'Essex Naturalist,' quarterly; 'Special Memoirs,' &c., occasionally.

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Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. Barclay Murdoch, Capelrig, Newton-Mearns, Glasgow	250	None	10*s.*	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	R. Brown, M.D., Belhaven House, Pollokshields, Glasgow	270	None	7*s.* 6*d.*	Transactions and Proceedings, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc.	Dr. Freeland Fergus, 207 Bath Street, Glasgow	1,000	1*l.* 1*s.*	1*l.* 1*s.*	Proceedings annually.
Halifax Scientific Society, 1874	Halifax S. S.	Literary and Philosophical Society's Rooms, Harrison Road. F. Barker	135	None	2*s.* 6*d.*	'Halifax Naturalist,' every two months.
Hampshire Field Club and Archæological Society, 1885	Hants F. C.	W. Dale, F.G.S., 5 Sussex Place, Southampton	250	None	7*s.* 6*d.*	Proceedings, annually.
Haslemere Microscope and Natural History Society	Haslemere Mic. N. H. Soc.	Rev. G. B. Stallworthy, The Manse, Hindhead, Surrey	400	None	Minimum 2*s.*	Report, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts N. H. Soc.	A. E. Gibbs, F.L.S., St. Albans, and T. E. Lones, M.A., Watford	200	10*s.*	10*s.*	Transactions, occasionally.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	G. E. Frisby, 1 Claudeboye Villas, Fengates Road, Redhill	108	10*s.* and 5*s.*	10*s.* and 5*s.*	Proceedings, every two or three years.
Hull Geological Society, 1857	Hull Geol. Soc.	J. W. Stather, F.G.S., 16 Louis Street, Hull	75	None	5*s.*	Transactions, annually.
Hull Scientific and Field Naturalists' Club, 1886	Hull Sci. F. N. C.	T. Sheppard, F.G.S., The Museum, Hull	180	None	5*s.*	Transactions, annually.
Institution of Mining Engineers	Inst. Min. Eng.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	2,600	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc.	E. G. Critchley, 29 High Street, Inverness	190	None	5*s.*	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland.	J. Pim, W. Lawson, and C. H. Oldham, 35 Molesworth Street, Dublin	100	None	1*l.*	Journal, annually.
Leeds Geological Association, 1873	Leeds Geol. Assoc.	Philosophical Hall, Leeds. Walter Parsons	83	None	5*s.*	Transactions, occasionally.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	W. M. Rankin, B.Sc., Cockburn Higher Grade School, Leeds	90	None	6*s.*	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. Herbert Ellis	333 Membs. & Associates	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Transactions, half-yearly.
Liverpool Engineering Society, 1875	Liverpool E. Soc.	R. C. F. Annett, 4 Buckingham Avenue, Sefton Park, Liverpool	515	None	Resident 1*l.* 1*s.* Non-Res. and Students 10*s.* 6*d.*	Transactions and Report, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc.	Capt. E. C. Dubois Phillips, R.N., 14 Hargreave's Bldgs., Liverpool	700	None	Members 1*l.* 1*s.* Associates 10*s.* 6*d.*	Transactions and Report, annually.
Liverpool Geological Society, 1858	Liverpool Geol. Soc.	Royal Institution. W. A. Whitehouse	63	None	21*s.*	Proceedings, annually.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	T. E. Acheson. Lloyds Bank, Ramsey, Isle of Man	135	2*s.* 6*d.*	7*s.* 6*d.* and 5*s.*	Yn Lioar Manninagh, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc.	Eli Sowerbutts, F.R.G.S., 16 St. Mary's Parsonage, Manchester	800	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Journal, quarterly; 'Geography,' monthly.
Manchester Geological and Mining Society, 1838	Manch. Geol. Min. Soc.	5 John Dalton Street, Manchester. W. Saint and J. Tonge, jun.	240	None	1*l.*	Transactions, monthly.
Manchester Microscopical Society, 1880	Manch. Mic. Soc.	E. C. Stump, 16 Herbert Street, Moss Side, and Charles Knight, 193 Oxford Street, Manchester	185	5*s.*	6*s.*	Transactions and Report, annually.
Manchester Statistical Society, 1833	Manch. Stat. Soc.	Theodore Gregory, 32 York Street, Manchester	216	10*s.* 6*d.*	10*s.* 6*d.*	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick	260	1*s.* 6*d.*	3*s.* and 5*s.*	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst.	G. Alfred Lewis, Albert Street, Derby	380	1*l.* 1*s.* None	Members 21*s.* 6*d.*; Associates and Students 20*s.*	Transactions of Institution of Mining Engineers, monthly.

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CORRESPONDING SOCIETIES, &c. (*continued*).

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	Midland Inst. Eng.	T. W. H. Mitchell, Mining Offices, Regent Street, Barnsley	300	None	1*l.* 10*s.*	Transactions of Inst. of Mining Engineers, monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich	258	None	5*s.*	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,300	None	25*s.* and 42*s.*	Transactions of Inst. of Mining Engineers, monthly.
North Staffordshire Field Club	N. Staff. F. C.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs; W. Wells Bladen, Stone, Staffs	461	5*s.*	5*s.*	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	Northants N. H. Soc.	H. N. Dixon, M.A., 23 East Park Parade, Northampton	190	None	10*s.*	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of	Northumb. N. H. Soc.	Hancock Museum, Newcastle-on-Tyne. Prof. M. C. Potter, M.A., and N. H. Martin, F.L.S.	450	None	21*s.*	Transactions, annually.
Nottingham Naturalists' Society, 1859	Nott. Nat. Soc.	Prof. J. W Carr, M.A., University College, Nottingham	188	2*s.* 6*d.*	5*s.*	Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst.	J. Gardner, 3 County Place, Paisley	500	5*s.*	7*s.* 6*d.*	Report, annually; Meteorological Obs., occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci.	Tay Street, Perth. S. T. Ellison	380	2*s.* 6*d.*	5*s.* 6*d.*	Trans. and Proc. annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, M.Sc., 105 Freehold Street, Rochdale	245	None	6*s.*	Transactions, biennially.
Rochester Naturalists' Club, 1878	Rochester N. C.	John Hepworth, Linden House, Rochester	180	None	5*s.*	'Rochester Naturalist,' quarterly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A. N. H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble, Rev. F. W. Weaver, and C. Tite	612	10*s.* 6*d.*	10*s.* 6*d.*	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc.	G. M. Clark, South African Museum, Cape Town	207	None	2*l.*	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	George Abbott, M.R.C.S., 33 Upper Grosvenor Road, Tunbridge Wells	40 Societies	None	Minimum 5*s.*	'South-Eastern Naturalist,' annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng.	Alexander Smith, M.Inst.C.E., 3 Newhall Street, Birmingham	178	1*l.* 1*s.* and 10*s.* 6*d.*	31*s.* 6*d.* and 21*s.*	Transactions of Institution of Mining Engineers, monthly.
Toronto, Astronomical Society of, 1884	Toronto Astr. Soc.	Canadian Institute Building. J. R. Collins	125	None	2 dollars	Transactions, annually.
Tyneside Geographical Society, 1887	Tyneside Geog. Soc.	Geographical Institute, Barras Bridge, Newcastle-on-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,200	None	10*s.* and 5*s.*	Journal, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C.	Museum, Warwick. C. West, Cross Cheaping, Coventry	99	2*s.* 6*d.*	5*s.*	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C.	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	240	10*s.*	10*s.*	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield	185	None	15*s.*	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	Yorks. Nat. Union	The Museum, Hull. T. Sheppard, F.G.S.	400 and 2,590 Associates	None	10*s.* 6*d.*	Transactions, annually; 'The Naturalist,' monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc.	Museum, York. Dr. Tempest Anderson and C. B. Rimbirst	490	None	2*l.*	Report, annually.

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Catalogue of the more important Papers, and especially those referring to Local Scientific Investigations, published by the Corresponding Societies during the year ending May 31, 1903.

*** This catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

ALLAN, H. STANLEY. The Photography of Sound Waves and other Disturbances in Air. 'Proc. Glasgow R. Phil. Soc.' xxxiii. 71–80. 1902.

—— The Potential Difference necessary for a Double Spark Gap. 'Proc. Glasgow R. Phil. Soc.' xxxiii. 215–218. 1902.

BEATTIE, Dr. J. C., and J. T. MORRISON. The Magnetic Elements at the Cape of Good Hope from 1605 to 1900. 'Trans. S. African Phil. Soc.' xiv. 1–27. 1903.

BICKHAM, S. H. Local Rainfall for the past Twenty Years. 'Trans. Woolhope N. F. C. 1900–1902,' 245–247, 1903.

BLACK, J. M. Heat Wave, United States. 'Journal Manch. Geog. Soc.' xvii. 229. 1902.

BLADEN, W. WELLS. Report of the Meteorological Section. 'Trans. N. Staff. F. C.' xxxvii. 109–113. 1903.

BLYTH, Prof. JAMES. Note on Additional Experiments with the Electric Sonometer. 'Proc. Glasgow R. Phil. Soc.' xxxiii. 267–268. 1902.

BRIGHTON AND HOVE NATURAL HISTORY AND PHILOSOPHICAL SOCIETY. Meteorology of Brighton, July 1901 to June 1902. 'Rep. Brighton N. H. Phil. Soc. 1901–1902,' 55. 1902.

BROWN, M. WALTON. Barometer, Thermometer, &c., Readings for the Year 1901. 'Trans. Inst. Min. Eng.' xxiii. 763–772. 1903.

BURTON-ON-TRENT NATURAL HISTORY AND ARCHÆOLOGICAL SOCIETY. Rainfall at Burton-on-Trent for the Years 1900, 1901, 1902. 'Trans. Burt. N. H. Arch. Soc.' v. 66. 1903.

CAMPBELL-BAYARD, F. Meteorological Report for 1901. 'Trans. Croydon M. N. H. C. 1901–1902,' 1–4, and Appendices of Tables, 53 pp. 1902.

CARADOC AND SEVERN VALLEY FIELD CLUB. Meteorological Notes, 1902. 'Record of Bare Facts,' No. 12, 49–61. [1903.]

CLARK, J. EDMUND. The York Rainfall. 'Report Yorks. Phil. Soc. for 1902,' 59–63. 1902.

CORNISH, Dr. VAUGHAN. The Snows of Canada. 'Proc. Dorset N. H. A. F. C.' xxiii. 58–66. 1902.

CRESSWELL, ALFRED. Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, Edgbaston, 1902. 'Birm. and Mid. Inst. Sci. Soc.' 30 pp. 1903.

DICKINSON, JOSEPH. Finding Mineral Veins by Electricity. 'Trans. Manch. Geol. Soc.' xxviii. 126–130. 1903.

EATON, H. S. Returns of Rainfall, &c., in Dorset in 1901. 'Proc. Dorset N. H. A. F. C.' xxiii. 134–145. 1902.

FIELDING, HENRY. Photographic Enlargements and the Kind of Negative Needed. 'Trans. E. Kent S. N. H. Soc.' ii. 7–10. 1902.

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FOURCADE, H. G. On a Stereoscopic Method of Photographic Surveying. 'Trans. S. African Phil. Soc.' XIV. 28–35. 1903.

GARDNER, H. DENT. The Scenery and Exploration of the Atmosphere. 'Trans. Eastbourne N. H. Soc.' III. 308–318. 1903.

—— and H. M. WHITLEY. The New Star in Perseus. 'Trans. Eastbourne N. H. Soc.' III. 295–297. 1903.

GILL, Sir DAVID. Annual Address. [The Work done at the Royal Observatory, Cape Town.] 'Proc. S. African Phil. Soc.' XIV. xxxvii–lxix. 1903.

GREENWOOD, Capt. W. NELSON. The Life of a Wave from its Cradle to its Grave. 'Journ. Manch. Geog. Soc.' XVII. 197–221. 1902.

GRUBB, Sir HOWARD, and HENRY DAVIS (Mid. Count. Inst. Eng.). The Grubb Sight for Surveying Instruments. 'Trans. Inst. Min. Eng.' XXII. 118–125. 1902.

GURNEY, Principal H. P. (N. Eng. Inst.). The Crumlin Meteorite. 'Trans. Inst. Min. Eng.' XXIV. 274–275. 1903.

HEYWOOD, H. Meteorological Observations in the Society's District, 1901. 'Trans. Cardiff Nat. Soc.' XXXIV. 1–21. 1903.

HOLMESDALE NATURAL HISTORY CLUB. Meteorology at Redhill, 1898, 1899, 1900, and 1901. 'Proc. Holmesdale N. H. C. 1899–1901,' 43–46. 1902.

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SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

PRESIDENT OF THE SECTION—CHARLES VERNON BOYS, F.R.S.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

THE first duty of every occupant of this Chair is a sad one. Year by year the record grows of those who have devoted their lives to the development of mathematical and physical science, of those who have completed their work. The past year has added many names to the record—more, it seems, than its fair share. The names include some of the most brilliant and active of our race, of those to whom this Association is deeply indebted, and also of our fellow workmen in other countries whose loss is no less to be deplored.

Lord Salisbury's devotion to the empire, of which this is not the occasion to speak, left him but little time for those scientific pursuits in which he took so keen an interest. Once, however, as President of this Association, he showed our members that, unlike the majority of our statesmen, science was not to him a phantom. His Address at Oxford will remain in the memories of all who heard it. The eloquence, the humour, the satire, the subtlety provided an intellectual treat of the rarest kind.

Of Sir George Gabriel Stokes and his work it is not possible for me to speak. Any attempt on my part to appreciate or gauge the value of the work of such a giant would be an impertinence. This can only fitly be done by one of our leaders, and Lord Kelvin has paid a fitting tribute in the pages of 'Nature.' I can only record the fact that Stokes was for seven years Secretary, and twice President of this Section, and in 1869 was President of the Association.

Dr. Gladstone, for fifty-three years a member of this Association, was not only an unfailing attendant at our meetings, but an active member whose steady stream of original communications on subjects connecting physics and chemistry earned for him the designation of Creator of Physical Chemistry. His investigations on spectroscopy, refractivity and electrolytics are known to every student of physics. His researches upon early metallurgical history, while of less importance to the progress of science, are none the less interesting. An ardent apostle of education, he was for twenty-one years a member of the London School Board, and three years vice-chairman. Dr. Gladstone was the first President of the Physical Society. He has been President of the Chemical Society, and at the last meeting of the British Association at Southport—as also in 1872—he was President of the Chemical Section. So long ago, he said, in urging the importance of science as a factor in education, that the so-called educated classes were not only ignorant of science, but had not arrived at the knowledge of their own ignorance.

It is not possible to pass on without paying a tribute, in which all who knew Dr. Gladstone will share, to his character no less than to his genius.

Sir William Roberts Austin was probably one of the most active members that this Association has known. Not only had he for many years made the subject of metals and alloys his own, but he worked for the Association in many ways. At

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three meetings have audiences been charmed by his fascinating and brilliant evening lectures, all relating to metals. He was President of the Chemical Section at the Cardiff meeting in 1891, and not only did he perform these duties, but he accepted the more laborious and more thankless task, for which his unfailing courtesy and tact so well fitted him, of acting as our General Secretary for four years. His labours in the important field of research which he tilled were appreciated by numerous technical societies and institutions of which he was an honorary member, or had been president or vice-president. Many branches of the public service had the advantage of his skill and experience, which received the official reward in 1899.

Dr. Common's skill as a designer and constructor of instruments was well known. His instinct or judgment in producing planes and figured concave mirrors of great dimensions was rare, for this is an art almost unknown in the laboratory. His generosity and his valuable advice have been appreciated by many besides myself.

Rev. H. W. Watson, Second Wrangler and Smith's Prizeman in 1850, was a Vice-President of the British Association in 1886. Mathematical physicists are familiar with the joint work of himself and Burbury on 'Generalised Co-ordinates,' and with his mathematical articles.

In Otto Hilger, the brother of the late Adam Hilger, who between them brought to this country German thoroughness and French skill in instrument manufacture, we have lost one of our first and most valuable constructors. Noted for the high class of all the optical work turned out by the firm, Otto Hilger was not afraid of attacking the problem of manufacturing the Michelson echelon grating. This little bundle of glass plates requires for its success perfection and precision commensurable only with the genius of the inventor. This Otto Hilger supplied.

Dean Farrar, a life member of the British Association, whose activity lay in another direction, showed his appreciation of the value of science in education by appointing the first science master at Marlborough when he became headmaster in the year 1870. As I was a boy at the school at that time, I can speak of the incredulity with which such an announcement was at first received and of the general feeling that such an action was akin to a joke. I was, however, by no means the only boy who hailed the news with delight. We devoured the feast of chemistry and physics put before us by Rodwell and the books which at once became available. Out of gratitude to the late Dean of Canterbury I recall this episode.

James Wimshurst, the inventor of the influence machine which has carried his name into every corner of the scientific world, was not a member of this Association, but he fostered and encouraged the scientific spirit in young men who, by good-fortune, came to know him. I do not think I have heard anyone spoken of with such gratitude and appreciation as Wimshurst, by men who in their younger days were allowed the run of his well-equipped workshop.

James Glaisher, best known as a balloonist in the sixties, has died at the great age of ninety-three. The balloon ascent with Coxwell on September 5, 1862, when they attained the altitude of 37,000 feet, will long remain in the popular imagination, not on account simply of the great altitude, but by reason of the sensational account of their having been paralysed with cold, and of their being able to stop the ever-increasing ascent only by the presence of mind of Coxwell, who, with his limbs frozen, seized the valve rope with his teeth, and so let out the gas.

While this event remains in everyone's mind, the more prosaic work of Glaisher in astronomy, meteorology, and photography, when most of us were children, and many yet unborn, led to his being elected president of various learned societies.

He gave one of the evening lectures of the British Association in 1863, the subject being balloon ascents.

A. F. Oaler, the inventor of the self-recording direction and pressure anemometer and rain gauge, whose active meteorological work was carried out in the first half of the last century, when he contributed papers to the British Association and the Literary and Philosophical Society of Birmingham, has died at the

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still greater age of ninety-five. He was Vice-President of the British Association in 1865.

Of other countries, America has lost Professor J. Willard Gibbs, a mathematical physicist whose very learned and original contributions to the knowledge of the world on the thermodynamical properties of bodies, on vectors, the kinetic theory of gases, and other abstruse subjects, have received the highest recognition that the learned societies of this country can bestow. Professor Harkness, the astronomer, and Professor Rood, the skilled experimental physicist of Troy, have also maintained the high standard that we now look for in American science.

Germany has lost Professor Deichmüller, Professor of Astronomy at Bonn, at an early age. Sweden has lost Professor Bjerknes, whose hydrodynamical experiments showing attraction and repulsion were so much admired when he performed them at a meeting of the Physical Society some twenty-five years ago. Switzerland has lost Professor C. Dufour, the astronomer; and Italy has lost Professor Luigi Cremona, a foreign member of this Association, Principal of the Engineering School in Rome, whose contributions to pure geometry and to its applications have made him famous.

Of the events of the last year, one stands out beyond all others, not only for its intrinsic importance and revolutionary possibilities, but for the excitement that it has raised among the general public. The discovery by Professor and Madame Curie of what seems to be the everlasting production of heat in easily measurable quantity by a minute amount of a radium compound is so amazing that, even now that many of us have had the opportunity of seeing with our own eyes the heated thermometer, we hardly are able to believe what we see. This, which can barely be distinguished from the discovery of perpetual motion, which it is an axiom of science to call impossible, has left every chemist and physicist in a state of bewilderment. Added to this, Sir William Crookes has devised an experiment, characteristic of him, if I may say so, in which a particle of radium keeps a screen bombarded for ever, so it seems, each collision producing a microscopic flash of light, the dancing and multitude of which forcibly compel the imagination to follow the reasoning faculties, and realise the existence of atomic tumult. Thanks to the industry and genius of J. J. Thomson, Rutherford and Soddy, Sir William and Lady Huggins, Dewar and Ramsay, and others in this country, besides Professor and Madame Curie and a host of others abroad, this mystery is being attacked, and theories are being invented to account for the marvellous results of observation; but the theories themselves would a few years ago have seemed more wonderful and incredible than the facts, as we believe them to be, do to-day. An atom of radium can constantly produce an emanation, that is something like a gas, which escapes and carries with it wonderful properties; but the atom, the thing which cannot be divided, remains, and retains its weight. The emanation is truly wonderful. It is self-luminous, it is condensed by extreme cold and vapourises again; it can be watched as it oozes through stopcocks or hurries through tubes, but in amount it is so small that it has not yet been weighed. Sir William Ramsay has treated it with a chemical cruelty that would well-nigh have annihilated the most refractory or permanent known element; but this evanescent emanation comes out of the ordeal undimmed and undiminished.

Not content with manufacturing so remarkable a substance, the radium atom sends out three kinds of rays, one kind being much the same as Röntgen rays, but wholly different in ionising power, according to the experiments of Strutt. Each of these consists of particles which are shot out, but they have different penetrative power; they are differently deflected by magnets and also by electricity, and the quantity of electricity in relation to the weight is different, and yet the atom, the same atom, remains unchanged and unchangeable. Not only this, but radium or its emanations or its rays must gradually create other bodies different from radium, and thus, so we are told, one at least of those new gases which but yesterday were discovered has its origin.

Then, again, just as these gases have no chemical properties, so the radium

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which produces them in some respects behaves in a manner contrary to that of all proper chemicals. It does not lose its power of creating heat even at the extreme cold of liquid air, while at the greater degree of cold of liquid hydrogen its activity is found by Professor Dewar to be actually greater.

Unlike old-fashioned chemicals which, when they are formed, have all their properties properly developed, radium and its salts take a month before they have acquired their full power (so Dewar tells us), and then, for anything we know to the contrary, proceed to manufacture heat, emanations, three kinds of rays, electricity, and gases for ever. For ever; well, perhaps not for ever, but for so long a time that the loss of weight in a year calculated, I suppose, rather than observed, is next to nothing. Professor Rutherford believes that thorium or uranium, which act in the same kind of way, but with far less vigour, would last a million years before there was nothing left, or at least before they were worn out; while the radium, preferring a short life and a merry one, could not expect to exist for more than a few thousand years.

In this time one gramme of radium would evolve one thousand million heat units, sufficient, if converted into work, to raise five hundred tons a mile high; whereas a gramme of hydrogen, our best fuel, burned in oxygen, only yields thirty-four thousand heat-units, or one thirty-thousandth part of the output of radium. I believe that this is no exaggeration of what we are told and of what is believed to be experimentally proved with regard to radium; but if the half of it is true the term 'the mystery of radium' is inadequate: the miracle of radium is the only expression that can be employed.

With all this mystery before us, which I must confess myself wholly unable to follow, I feel sure that members of the Association who are interested in the work of this Section will welcome the discussion, for which our secretaries have been able to arrange, and hear from the lips of Professor Rutherford the conclusions to which his researches have at present brought him. No one is more fitted than Professor Rutherford to open such a discussion, for no one has attacked the theoretical side with such originality and daring, or with such ingenuity of experiment.

As an example of the activity of mind and of research to which the activity of radium has given rise, I may mention the fact that the last number of the 'Proceedings of the Royal Society' is wholly concerned with radium, there being four papers, all of the first importance, dealing with entirely different phenomena.

It is not my purpose to review these or the subject of radium generally; I am in no way fitted to do so. But I cannot well let the present opportunity pass of referring to another mystery of which a conspicuous example is now leaving us. I refer to the mystery of the comet and its tails. What is a comet? of what does its tail consist? Gravitational astronomy has told us for many years past that compared with the planets or their satellites a comet does not weigh anything. It weighs pounds or perhaps hundreds, thousands, or millions of tons; but in comparison with inconspicuous satellites it weighs nothing. Yet some of them as they approach the sun from remote regions begin to shoot out streamers which pour away as though repelled by the sun, not being left as a trail behind the comet, as is so often supposed. These streamers, ejected towards the sun, bend round and pour away at speeds which are enormous compared with that of the comet itself, thus producing the tail. Now these streams separate very often, and give rise to comets with two or three tails.

The comet's tail is still a mystery. Let me take the most recent explanation, which was set forth only three months ago in the 'Astrophysical Journal' in the United States. Those admirable experimentalists Nichols and Hull have for some years been investigating the back pressure exerted by the action of light upon bodies on which it falls. In this they have followed the Russian physicist Lebedew, but in minuteness and delicacy of measurement, and in their successful elimination of disturbances, their results are unequalled. It is sufficient to say that, difficult and minute as the experiment is, their success is such that the discrepancy between the calculated force and that which they have found is under 1 per cent. Perhaps I may express some satisfaction that in this measurement use was made of the quartz fibre.

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Having now definite and accurate confirmation of the existence of the force produced by the action of light, or rather radiation, Nichols and Hull proceed to examine the question as to how far such repulsion may be competent to overcome the gravitative attraction of the sun and drive away the matter which pours out from the comet. It is interesting to note here that Kepler put forward this very idea, and that Newton, the inventor of the corpuscular theory of light, looked upon the suggestion with some favour.

Coming now to this recent paper of Nichols and Hull, we find first the consideration of the relation of the attraction by gravitation, and the repulsion by light upon particles of different sizes and densities. Density has no influence on the action of light, while it is favourable to gravitation, and therefore unfavourable to tail formation. Size is favourable to both, but more to gravitation than to light, for if the diameter of a particle be doubled, one is increased eightfold and the other only four. So size favours gravitational attraction. Conversely, of course, smallness favours repulsion by light, which relatively should get greater and greater as the particles diminish in size. At last, then, a degree of smallness may be reached in which the repulsion by light will actually be equal to the attraction by gravitation, and such a particle would remain in space, its motion unaffected by our sun. Let the diminution of size continue, and then the repulsion will be in excess, and if the law were to continue it would with sufficient diminution become relatively as large as we please.

The law, however, does not continue. Schwarzschild has shown that when the particles are small enough, light does not act upon them in the same way. Owing to diffraction, the effect of light is unduly great for a certain very small size of particle, while it fails almost entirely when the particle is made much smaller. Thus it is that the indefinite increase in the repulsion by light as compared with the attraction by gravitation with diminution of size of particle is checked, and when, according to theory, with a particular density of particle, the light pressure is about twenty times as great as gravitational attraction, further diminution of size ceases to favour the action of light, and it begins to fall off again. The distance of the particle from the sun has no influence upon the relation between the two kinds of forces, for they rise and fall together. Nichols and Hull, therefore, while not denying that other causes may operate, believe that light pressure is adequate to account for the phenomena, and that where the material coming from the head or comet proper is of two or three kinds, whether of density or of size of particle, the separation of the two or three tails should naturally follow.

This theory presupposes that the nucleus of a comet will be able, owing to the evolution of gas under the sun's heat, to send out enormous quantities of dust, the finer and lighter the better, so long as it is not unduly small with respect to a wave-length of light. Such dust would account for any reflected solar light that the spectroscope may show, but it is not easy to see how the spectrum of hydrocarbons, of sodium, and of other metal, should be produced for lack of temperature. It is not easy to see why fortuitous dust should be graded of such sizes as to give well separated and defined tails; it is not easy to see how the dust could be produced in sufficient quantity to provide visible illumination to millions of millions of cubic miles of space through which it may be passing at ultra-planetary velocity, even though in looking through a million miles or so one grain of dust in a hundred miles might suffice to supply the light.

Other theories of the comet's tail require an electrified sun, the existence of which is explained by Arrhenius as being caused by the emission by the sun of negatively charged electrons which, picking up condensing gases as Aitkins's dust picks up moisture from the atmosphere, are driven away by the light pressure. Arrhenius believes that these acting on the matter in the tail would give rise to the bright line spectra which have been observed. The result of all this escape of negative electricity is a positively charged sun, but what limits the charge in the sun it is difficult to see, as it is, why the electrostatic attraction helped by gravitation does not ultimately stop the action.

Nichols and Hull, while calling to their aid the researches of Schwarz-

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schild to give them a repulsive force some twenty times as great as gravitative attraction, do not seem to have given due weight to the extremely small range of size of particle for which this high effect is available. The maximum effect for any wave-length according to Schwarzschild is produced, when the size is such that a wave-length will just reach round it; that is, with ordinary light when the diameter is between one hundred thousandth and one hundred and fifty thousandth of an inch. If the diameter is two-and-a-half times the wave-length the action of light is only equal to gravity with a material of the density of water; or again, if it is reduced to one-eighth of a wave-length it again becomes equal, and in these two cases there is no resultant action. With either larger or smaller particles gravity rapidly gets the better of light, while the high advantage of light over gravity is confined to very narrow limits.

What the sifting process can be that will give rise to such a quantity of this microscopic dust we can hardly expect to be told, nor why even if the material should in some mysterious way be graded, the ungraded wave-lengths of the solar spectrum should allow of the marked separation in some instances of comets' tails.

One thing, however, they do assert, and that is that the light pressure can have no action on a gas, so that if what we see is considered to be gaseous the light pressure theory must be thrown over for some other.

I cannot leave this excursion of Nichols and Hull into a speculative domain of science without expressing my admiration of the experimental work which they have accomplished, or of my appreciation of the ingenuity and daring with which they have attempted the hitherto unheard-of feat of making a comet.

While the theory just referred to may be the most recent it must not on that account be supposed to displace all that has gone before; the authors themselves do not suggest this; it is the last thing that would occur to them. They have referred to the researches of Bredechin that occupy so large a proportion of the annals of the Observatory of Moscow.

It is impossible to read even a tithe of these without feeling that the subject of comets and their tails is one which Bredechin, by his amazing industry, has made his own property, and that any stranger casually passing by and taking a random shot should receive the severe penalty awarded to poachers in this country. Bredechin has dealt unmercifully—I do not say unjustly—with the author of at least one such random theory.

It is therefore with the greater diffidence and more urgent plea for forbearance that I venture to draw certain parallels and hazard certain suggestions which I admit freely have not reached a stage at which detailed comparisons with known comets are possible.

It does not seem possible now to contemplate the phenomena of the comet, of the divided tails, of their tenuity and transparency, of the pale luminosity, partly reflected solar light, partly light as from a glowing gas; of the gradual wearing out and disappearance of those comets which constantly pay visits to solar regions, with all the mysteries of radium now so much in evidence without tracing the features in which they resemble one another. By radium, of course, I mean any material with the remarkable radio-active properties that radium exhibits with such pre-eminent splendour, whether known in the laboratory or not.

How many physicists have been peering at comets through radium spectacles, or how many astronomers detect the sparkle of radium in the fairy tresses of their hirsute stars I know not. One writer, however, T. C. Chamberlin, so long ago as July 1901, looked upon a connexion between radio-active materials such as were then known and comets as at least worth considering. Chamberlin's paper in the 'Astrophysical Journal' was mainly on the tidal disruption of gravitating bodies and the possible evolution of comets, nebulæ and meteorites, and he did not pursue this consideration in any detail; indeed, the enormous accumulation of new properties of radium was not then available.

Whatever may be imagined as to the constitution of a comet, difficulties still remain. All I suggest now is that the curious properties of radium and of similar bodies should be kept in mind. Radium at least supplies the means by

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which, if the increasing warmth or the tidal action of the sun should awaken its activity, Rutherford's α-rays should be shot out at the speed that he has measured of a thousand million inches a second, *i.e.* one-twelfth the velocity of light. These α-ray particles, according to Rutherford, consist of helium; they weigh each twice as much as a hydrogen atom, and so the same weight of comet matter that would make one of Nichols and Hull's best particles, *i.e.* one that would be just visible with a microscope, would be sufficient for about 400 millions of Rutherford's α-ray particles, an advantage surely where diffuseness seems so miraculous.

These particles, shot out at a velocity one-twelfth that of light, go so fast that, if they were to start horizontally on the surface of the earth, the gravitative attraction of the earth would curve their path to the infinitesimal extent of a curve with a radius of forty-thousand million miles. Yet so great is the electric charge they carry that a visible curvature can be imposed upon them in a practicable electrostatic field.

Now imagine these transferred into space at a distance from the sun, for instance, equal to that of Venus. Gravity there due to the sun is only one-thousandth of what it is here, so gravity there would be, to the same extent, less able to impose visible curvature on their paths. But their electric charges are still available, and unless I have made an arithmetical blunder of a considerable order, it would require no very heavy electrification of the sun to bend these rays round in a curve with a radius of 1,000 miles. An electrostatic field of under two ten-thousandths of a unit should be sufficient, a field which would be produced if the sun were only charged with a surface density of one electrostatic unit on every three square centimetres.

Whether these figures are correct or not—and I know the risk of getting just thirty-thousand-million times too large or too small a result—does not much matter. An electrified sun, which after all others besides Arrhenius have postulated, would be sufficient to turn the rays and send them away at rapidly increasing speed so as to form the tail. The speed would in a short time reach the velocity of light if it were not for the change in properties of matter which supervenes when any such velocity is nearly reached. Thus, according to the ratio of charge to mass, particles such as those in Rutherford's α-rays would be sent away each with its limiting velocity, giving rise to streaks more or less well defined, and double, triple, or multiple according to the number of kinds of ray which the various radio-active materials were able to generate.

Not only should streaks pointing away from the sun be formed, but any negatively charged rays such as radium is said to give out should form a tail directed towards the sun. Perhaps this might be expected to be general, but while not common one was described by Hind in the comet of 1823–24, and three or four more have been observed.

The head or coma would be the envelope of all the independent orbits, leaving the nucleus in all directions—orbits which while their velocities are still of the Rutherford order would be hyperbolas convex to the sun.

If this should not appear to be absolute nonsense it would seem as if another difficulty should become less than it has been. I refer to the visibility, luminosity, and spectral character.

Lodge, as an interpreter of Larmor, tells us that an electrified ion subject to acceleration, whether transverse or in the line of motion, radiates energy. The streamers from the nucleus subject to the greatest acceleration may be bright almost as the nucleus itself; then, as they have become dissipated into regions where far less acceleration becomes possible, the radiation falls off and the tail is lost in space.

The observations made last month by Sir William and Lady Huggins of the spectrum given by a piece of radium in the air may have some bearing upon the luminosity of the comet. It is possible that the internal motions set up by the separate parts, each pursuing its individual orbit, may produce collisions numerous and violent enough to account for all the light that is seen, and for temperature sufficient to bring out the spectral lines that have been identified. Whether this is so or not, radio-active bodies and their emanations can produce light indepen-

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dently of such action; and now these observers have found that in the case of radium in air this light gives the spectrum, line by line, of nitrogen. Is it possible that the enveloping nitrogen has had its atoms so harried by the activity of the radium as to give a response hitherto only awakened by electric discharge? The ability to obtain such a response opens up a new possible interpretation of these spectra, which hitherto have been assumed, with our laboratory experience only to guide us, to have required for their production temperature above a red heat. If further observation should confirm this, the hydrogen, the hydrocarbon, and possibly even the sodium or iron spectrum that has been observed, may have come from cold atoms; and it is not even quite beyond the limits of imagination to picture, not from the comet matter itself, but from loose residual and highly attenuated matter through which the comet is passing.

There is one other feature of this remarkable observation of equal interest. The lines of the spectrum were not exactly in their proper place, but were all shifted towards the red end of the spectrum about twice the distance between the D lines. If only one or two lines had been so observed a different origin might well have been suspected; but when the whole series are faithfully reproduced it is reasonable to look upon the spectrum as modified to that extent as though the works of the nitrogen atom had not only been set in movement, but had been loaded with the radium emanation.

Before dismissing these random speculations on the possible connexion between radio-activity and comets I would ask your leave to refer once more to Bredechin's conclusions. He has found that it is merely necessary to postulate three kinds of matter, issuing from the nucleus with three initial velocities, and subject to repulsion from the sun with three sets of forces of repulsion—*i.e.* as compared with ordinary gravitative attraction—for the whole of the phenomena of all sorts of comets to be very completely accounted for. His highest initial velocity is only about five miles a second, and his lowest about a quarter of a mile a second. His highest repulsion, after deducting gravitative attraction, is only eleven times gravity, and his lowest only a fifth of gravity. If, then, with such velocities and forces the phenomena can be exactly accounted for, it would seem futile to consider the possibility of initial velocities from 4,000 to 80,000 times as great and effective repulsions of a corresponding order being able to produce effects with anything in common. This is not necessarily the case, for with the comparatively slow separation of the atoms of Bredechin's matter from the nucleus, each one describing its own hyperbola convex to the sun, the tail at any moment represents the then position of any number of atoms which left the nucleus for some distance back, whereas with the enormous velocities and effective forces now discussed the comet moves so slowly in comparison that the tail would practically represent the path at the time.

It has taken me far longer to throw out this not very luminous ray than I had expected or than it is worth. I fear that it is a sort of ray in which the ratio of its dead weight to its vitalising charge is too small to enable it to penetrate the lightest screen of examination.

These are the days of rays, and now before we have quite become familiar with the rays of radio-active bodies Blondlot has presented us with N rays, which issuing from the mantle of an incandescent gas burner penetrate wood or aluminium, and then increase the light without increasing the heat of hot bodies on which they fall.

Passing now from the amusement of speculation to more serious duties, I find myself confronted with the difficulties that prevent us in this country from succeeding as we used to do in the international struggle—a struggle the issue of which is daily becoming more and more a question of brains, of education, of skill and enterprise in manufacture—and finally of that great virtue extolled by the President of the United States, strenuousness.

It is the duty of everyone who sees the way in which we are being outstripped in the race to do what in him lies to scrape off the rust which is clogging our educational machinery. I now refer to the defects which hamper the intellectual

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progress of the majority of our youth. I believe the public school mathematics in this country stands on a level of its own, well below that of any other. In England, owing to our complicated system of weights and measures, which our Ministers and our Parliament dare not abolish for our own good, the scanty hours allowed for mathematics are devoted to the learning of tables which should never have to be learned at all, to compound reductions designed merely to puzzle but not to lead to any new step; and, even if our present system were not futile enough, to learning lists of antique values which serve the useful purpose of giving the boys something to do. The result is that beyond having time to acquire a few elementary algebraical rules the boy is never introduced to algebra proper; he has no idea of algebraical reasoning; his trigonometry often does not exist, and the very sound or suggestion of coordinate geometry or of the differential calculus, which might be well within his reach, produces a shiver of dismay. Geometry is presented for the first time in the form of Euclid, a form as repulsive to most boys as it well could be. I must confess to having been attracted and not repelled by Euclid; but the boy does not care for time. Now that I look at Euclid again I have also to confess that any lingering regard for an old friend vanishes before the archaic language and the unnecessary circumlocution. If Euclid must be retained let it be translated into English, the English that any parent would use in explaining the ideas to his son; let it be illustrated by constant reference to real things so as to appeal to the boy who does not revel in the abstract. Let the ideas and the terms first be presented in the form of experiments and of measurements with instruments; let the schoolmaster dare to throw over the intolerable conservatism which prevents our doing anything ten times as well lest some item should prove to be a trifle worse; in fact, let us take some heed of the possibly extreme, but none the less genuine, and valuable preaching of Professor Perry. I have so far referred only to the miserable use that is made of the odd hours grudgingly given to what is called mathematics. Is it any use to repeat the long-standing complaint of the way in which the schoolmaster insists upon overdoing his Latin and Greek under the belief that they are at least essential to intellectual development if, indeed, they do not supply the only stimulus? As society is constituted they are essential to education as an extensive knowledge of Confucius is essential to an educated Chinaman, so that we may mix one with another, appreciate the works of our great authors, understand the same allusions, and have the same kind of knowledge of the development of our civilisation. Few men of science, perhaps none, wish to see all of this, some of which is essential to a general education, abolished; all that we ask is that the schoolmaster shall not continue to impose upon the community the unbalanced learning which corresponds to mathematics and science without letters. The time given to classics is exorbitant; more must be reserved for those pursuits which draw out the habit of independent thought, creation and originality. It would be well if every schoolmaster could read an admirable article by James Swinburne on the two types of mind fostered by the two complementary types of education, but this is buried away in an inaccessible number of the 'Westminster Review.'

The classic is unfortunately still in possession, and where, as is still often the case, he is innocent of any appreciation of the educational value of post-Newtonian studies it is not surprising that he thrusts into odd moments the subjects he does not understand, and which he therefore despises, and that the boys committed to his charge and living in such an atmosphere are half ashamed of showing any interest in the scanty science which is within their reach. It is almost impossible to believe that such can be the case, but I have referred to the impression to which the appointment of the first science master at my own school gave rise. I now refer to the contribution to a discussion on education but a year or two ago by that experienced teacher, Principal Griffiths. Fortunately our public schools are not the only ones in the country. Smaller and less fashionable schools pay more attention to education and suffer less from what, in defiance of all rule, I can only call didactatorial method.

I am not aware that the result of this almost total exclusion of tabooed sub-

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jects in favour of Latin and Greek is producing a standard of classical attainment in our youth greatly in advance of that to be found in other countries, but it is certain that in history, modern languages, mathematics, and science the product of our public schools is sadly deficient.

There is another point related to our deficient general scientific training on which I wish to offer some remarks, and that is in relation to manufacture. It is the fashion among some of our scientific people to talk of our manufacturers as if they were a very ignorant lot and to suppose that one word from some professor who has never seen outside a laboratory would be sufficient to put them right. Now in my somewhat varied experience I have had occasion to become acquainted with corners of our great manufacturing areas, and while my experience is small and not enough to generalise upon, it is nevertheless several times as great as that of some who are ready to adopt the superior attitude, but have none.

The loss of one industry after another is only too patent. In so far as this may be due to want of enterprise in our men of business we are not concerned with the cause in this Section; in so far as it may be due to want of that little assistance which the fiscal arrangements in other countries make possible for our rivals again we are not concerned in this Section; in so far as our patent laws are unique among those of manufacturing nations in allowing the foreigner to manufacture in his own country under the protection of our patent law, so that the most valuable school we possess, the manufactory, as well as the manufacture, is conducted to the advantage of our rivals—a point which I suppose it is unnecessary to commend to the notice of Mr. Chamberlain—with this, too, we have no concern in this Section; but in so far as this, or the want of enterprise or of foresight that leads to it, is due to ignorance and to want of appreciation of scientific advance we are very much concerned with it. If I may refer to my own limited experience, there is a lamentable contrast in the manner in which a great number of our own countrymen look at any proposition put before them and that in which the alert American does. It is useless to explain that which would be self-evident to a man with a moderate knowledge of chemistry and physics such as our schools ought to supply, or for which they should at least lay the foundation, for the words have no meaning; they are merely words. He distrusts anything new; he has heard of a new process before that did not work out well; experience on the Continent to him is no experience at all, for he believes the inhabitants in such distant parts of the earth are not capable of knowing as well as the enlightened Englishman whether a thing is properly done or not, and so he goes on as he did before, perfectly content. This attitude would not be possible with the most elementary understanding of common principles.

But there is another side to this picture. Anyone who has discussed any scheme with the board of directors, the manager, the engineer, and the chemist of one of our great manufactories must have been struck with the concentrated ability there found in harness. It has often seemed to me that it is a great misfortune that our professors of mechanics, of physics, and of chemistry are in so many instances precluded from a better acquaintance with the working of these great machines—a misfortune not for the works, at least directly, but for the professors, and more especially for their pupils.

Nowhere are scientific problems of greater complexity constantly having to be solved than in a great manufactory; nowhere is such concentrated talent necessary as in a works organised and carried on in competition with all the world. I look upon these as our most valuable schools, and the closer the touch between them and those whose province it is to teach, the better for the teacher and the pupil.

It is, perhaps, hardly desirable to mention any one where there are so many. I am tempted to dwell upon the problem which has been at last successfully solved by Parsons, this being the joint product of the school and of the works; but there is one picture—a contrast, I will not say of light and shade, but of colour and colour—to which I must refer. I remember in my early days, in the surroundings of a classical atmosphere, the general feeling of contempt for the manufacturer, the intellectually inferior creature who only made money, but who knew nothing of *τύπτω* or *τέτυμμαι*. I am not sure that some such feeling does not still exist among

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those whose horizon is limited to the Latin and Greek that they have learned—or should I say limited *by* instead of *to*? This recollection came back to me when not long ago I was visiting one of the best organised and most skilfully conducted works in the country—I mean Willans & Robinson—when I remembered that another great manufactory, conducted on American lines, was near by, and when across the road I saw the walls of one of our most famous English schools. I pictured the old contrast: on the one hand the conviction impressed upon me when a boy that there is something intellectually superior in the struggle with a paragraph of Xenophon or a page of Homer, while manufacture is merely mechanical, sordid and base, with what I believe to be the reality on the other. I wondered in what spirit the erection of these works was viewed at the school and to what extent the high intellectual attainment there so essential and so evident is properly appreciated.

Of the last of the three headings, Strenuousness, we have plenty, but at school it is most apparent in cricket and football, and in after life in various expensive ways of murdering defenceless animals.

However, a change is already beginning to be felt. The public schools no longer withhold the elements of chemistry and physics, and those who have benefited, even in small degree, are taking responsible places vacated by those who had no such opportunity. The numerous polytechnics are providing more serious instruction to thousands of our young men, and it may be hoped that in time even the official—I mean the mere official whose only conception of activity is centred in obstructing progress and enlightenment—will have some appreciation of things as well as of words.

The following Papers were read:—

1. *On the Electro-ethereal Theory of the Velocity of Light in Gases Liquids, and Solids.* *By* Lord KELVIN, *O.M., G.C.V.O.*[1]

This communication is an advance proof of the last five pages of Lecture XX., as written afresh for a long-promised volume of twenty lectures, given originally in the Johns Hopkins University, of Baltimore, U.S.A., in October 1884, and now nearly ready for publication by the Cambridge University Press. It is founded on two recent contributions to 'electro-ethereal' theory referred to as 'Appendix D' and 'Appendix A,' previously published in the 'Philosophical Magazine' (1902, 1st half-year, and 1900, 2nd half-year), under the titles 'Aepinus Atomized,' and 'On the Motion produced in an Infinite Elastic Solid by the Motion through the Space occupied by it of a Body acting on it only by Attraction or Repulsion.' The long title of Appendix A contains virtually a complete statement of the theory which constitutes its subject.

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2. *Discussion on the Nature of the Emanations from Radium. Opened by* Professor E. RUTHERFORD.

Contribution by Lord KELVIN, *O.M., G.C.V.O.*

Let us first consider the mere fact, now known as a result of observation and experiment, that radium has been found to emit three types of rays:—

α, Positively electrified, and largely stopped by solid, liquid, or gaseous screens.

β, More penetrative than α, and negatively electrified.

γ, Electrically neutral, and much more penetrative than either α or β; passing with but little loss through a lead screen 1 centimetre thick, which is an almost perfect screen against α and β rays.

A simple *prima facie* view is to regard the 'γ rays' as merely vapour of radium.

[1] Appeared in full in *Phil. Mag.* vol. ii. October 1902.

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The 'β rays' seem certainly to be atoms of resinous electricity—electrions, as I have called them (to specialise Johnstone Stoney's 'electron,' which might be either a vitreous or resinous atom of electricity, or an atom of matter deprived of its natural quantum of electricity). The 'α rays,' according to my proposed atomic resuscitation of Aepinus's doctrine, are atoms or molecules of matter, probably atoms of radium, or perhaps molecules of bromide of radium, either deprived of electrions, or having less than their neutralising quantum.

The electro-ethereal hypothesis, referred to in my communication of last Thursday to Section A, affords a ready explanation of the relative penetrativities of the three radiations, and of the fact that each one of them makes its existence known to us by conferring electric conductivity on air or any ordinary gas in which it is present.

Taking the γ rays first, we have to explain the free penetration of unelectrified radium molecules through dense liquid or solid matter. An easy assumption suffices: let the Boscovichian mutual forces (that is, the chemical affinities and the repulsions) between an atom of radium and the atoms of lead and other permeable substances be absolutely zero, or small enough to allow the known permeation.

Taking, next, the α radiation. The apparent great absorption of the vitreous electric emanation from radium is only apparent; it means that an atom shot from radium with less than its neutralising quantum of electrions cannot go far through a solid or liquid without acquiring the neutralising quantum.

The β absorption may be regarded as probably real. Atoms of resinous electricity shot from radium cannot be expected to enter a screen of metal, or glass, or wood, or liquid, and leave at the other side, irrespectively of the insulation of the screen and of the radium. The full consideration and experimental investigation of the emission of atoms of resinous electricity from radium hermetically sealed in a glass bulb or tube is forced upon us. It has, I believe, led to surprising and interesting results. As to the γ rays, there is no difficulty in supposing that non-electrified vapour of radium passes very freely through glass or metals without any electric disturbance. It has been published, on authority so far as I know unquestioned, that loss of weight in the course of a few months has been proved. Full information on all that is known on this subject will no doubt be brought forward in the course of the discussion to be opened by Professor Rutherford. I regret much that I am not able to be present, and I shall look forward with eagerness to the earliest published reports of the discussion.

Returning to Becquerel's original discovery in respect to uranium and salts of uranium, the electric conductivity induced in air and other gases by a radio-active substance; we have a ready explanation in my atomic resuscitation of the old doctrine of Aepinus. The ordinary thermal motions within any solid, or liquid, or gas, must cause occasional shootings out of the electrions from the substance, and the motions of these electrions under the influence of electrostatic force must contribute to the electric conductivity of the gas; must, in fact, constitute all of it which is not due to transport of atoms of the gas carrying less than the neutralising quantum of electrions. Thus every substance, solid, liquid, or gas, must possess radio-activity. It is exceedingly interesting to find in Strutt's short paper 'On Radio-activity of Ordinary Materials,'[1] that the electric conductivity of dry air contained in a cylinder of solid material differs largely for different materials (1·3 for glass coated with phosphoric acid, 1·4 aluminium, 2 to 3·3 various ordinary metals, 3·9 platinum); and to be told that radium is 300,000,000 times more active than the most active common material that he experimented with. How are we to explain this enormous radio-activity of radium? I venture to suggest that it may be because it is exceedingly poly-electronic; that the saturating quantum of electrions in an atom of radium may be hundreds, or thousands, or millions of times as many as those of atoms of 'ordinary material.'

But this leaves THE mystery of radium untouched: Curie's discovery that it (perpetually?) emits heat at a rate of about 90 Centigrade calories per gramme

[1] *Phil. Mag.* June 1903.

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per hour. If emission of heat at this rate goes on for little more than a year, or, say, 10,000 hours (13¼ months), we get as much heat as would raise the temperature of 900,000 grammes of water by 1° C. It seems to me utterly impossible that this can come from a store of energy lost out of the gramme of radium in the 10,000 hours. It seems to me, therefore, absolutely certain, that if emission of heat at the rate of 90 calories per gramme per hour found by Curie at ordinary temperatures, or even at the lower rate of 38 found by Dewar and Curie from a specimen of radium at the temperature of liquid oxygen, can go on for month after month, energy must somehow be supplied from without to give the energy of the heat getting into the material of the calorimetric apparatus.

I venture to suggest that somehow ethereal waves may supply energy to the radium while it is giving out heat to the ponderable matter around it. Think of a piece of black cloth hermetically sealed in a glass case, and sunk in a glass vessel of water exposed to the sun; and think of another equal and similar glass case containing white cloth, submerged in an equal and similar glass vessel of water, similarly exposed to the sun. The water in the former glass vessel will be kept very sensibly warmer than the water in the latter. This is analogous to Curie's first experiment, in which he found the temperature of a thermometer, with a little tube containing radium kept beside its bulb, in a little bag of soft material, to be permanently about 2° C. higher than that of another equal and similar thermometer, similarly packed with a little glass tube not containing radium beside its bulb.

By observing the temperature of the water in our two glass vessels, a calorimetric investigation might be made, showing how much heat is given out per hour by the black cloth to the surrounding glass and water. Here we have thermal energy communicated to the black cloth by waves of sunlight, and given out as thermometric heat to the glass and water around it. Thus we actually have energy travelling inwards through the water in virtue of waves of light, and outwards through the same space in virtue of thermal conduction.

My suggestion respecting radium may be regarded as utterly unacceptable, but at all events it will be conceded that experiments should be made comparing the thermal emission from radium wholly surrounded with thick lead with that found with the surroundings hitherto used.

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3. *Über die in der Atmosphäre und im Erdboden enthaltene radioaktive Emanation.* *Von* T. Elster *u.* H. Geitel.

Wir beehren uns der *British Association* hiermit eine kurze Übersicht der Ergebnisse von Versuchen vorzulegen, deren Gegenstand die, wie es scheint, allgemein verbreiteten radioaktiven Eigenschaften der natürlichen atmosphärischen Luft und gewisser Bestandteile des Erdbodens bilden; sie beweisen in ihrer Gesamtheit die Existenz einer *radioaktiven Emanation* in der Atmosphäre, die, wenn nicht ausschliesslich, so doch zu einem wesentlichen Teile aus dem Erdkörper herstammt. Eine Mitteilung darüber dürfte im Zusammenhange mit der heutigen Diskussion über die Natur der aktiven Emanationen vielleicht nicht ohne Interesse sein.

Die Versuche bezogen sich:

1. Auf den Betrag der inducierten Aktivität, die man auf einem beliebigen Leiter (am besten einem Drahte von unveränderlicher Länge) dadurch erzeugt, dass man ihn eine gemessene Zeit lang in freier Luft zu einem bestimmten Potentiale negativ geladen hält.
2. Auf Vergleichung des Gehaltes an radioaktiver Emanation in der an verschiedenen Orten im Erdboden enthaltenen Luft.
3. Auf die radioaktiven Eigenschaften der mineralischen Bestandteile des Erdbodens selber.

In Betreff des ersten Gegenstandes haben wir gefunden, dass die unter gleichen Bedingungen durch die freie Luft inducierte Aktivität in der Nähe der Meeresküste

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kleiner ist, als an unserem etwa 250 Kilometer davon entfernten Wohnorte, und hier wiederum kleiner als am Fusse der Alpen. Die Beträge der Aktivierung verhielten sich an diesen Orten (im Mittel aus zahlreichen Einzelmessungen) etwa wie 1 : 4 : 30.

Weiter zeigte sich, dass die aus der Erde angesaugte Luft im Allgemeinen einen abnorm hohen Gehalt an radioaktiver Emanation mit sich führt. Dieser ist indessen nicht an allen Orten derselbe; so erwies sich Luft aus Kalkboden stammend schwächer aktiv als solche, die aus tonigen Erdschichten entnommen war. Auch die natürliche Kohlensäure, die aus altem vulcanischen Boden am Nieder-Rhein aufsteigt, ist mit Emanation beladen. Es ist kein Zweifel, dass auch die Radioaktivität der in gewissen Brunnenwässern enthaltenen Luft, die von Herrn J. J. Thomson konstatiert ist, von derselben Natur ist.

Hiernach würde der Reichtum an Emanation in der Luft des Binnenlandes wahrscheinlich darauf zurückzuführen sein, dass diese in unmittelbarem Austausche mit der in den Kapillären des Erdbodens eingeschlossenen Luft steht. In Einklang mit dieser Auffassung steht die Erfahrung, dass im Allgemeinen bei sinkendem Barometer (d.h. während des Einströmens von Erdbodenluft in die Atmosphäre) eine grössere Aktivierung für exponierte Drähte beobachtet wurde, als bei stationärem oder steigendem.

Ferner fanden wir dass Proben von Erde, von der Oberfläche entnommen, bei der Berührung mit abgeschlossenen Luftmengen an diese eine deutlich nachweisbare Menge einer radioaktiven Emanation abgeben. Mit festem Gesteine erhielten wir diese Wirkung nicht; ebenfalls nicht mit reinem Humusboden und Quarzsand. Am deutlichsten war sie beim Ton; wurde derselbe durch verdünnte Salzsäure vom Calciumcarbonat befreit, so blieb die Wirkung an dem ungelösten Rückstande haften. Eine Abnahme der Wirksamkeit im Laufe der Zeit konnte an aufbewahrten Proben von Erde bis jetzt noch nicht (während eines Jahres) nachgewiesen werden. Sehr gut zu erkennen ist die Erscheinung bei dem sogenannten Fangoschlamme, der zu Heilzwecken aus Italien importiert wird; eine Menge von etwa 5 Kilogramm davon in trocknem Zustande in einen Raum von etwa ½ Kubikmeter gebracht verbreitet in der eingeschlossenen Luft so viel an aktiver Emanation, dass diese leicht nach der Methode der Herrn Rutherford an der Aktivierung eines eingeführten negativ geladenen Metalldrahtes nachgewiesen wird.

Die Abnahme der so inducierten Aktivität in der Zeit erfolgt nach einem Exponentialgesetze, das von dem für die Thoriumemanation gültigen durchaus verschieden ist, dem für das Radium bekannten aber sehr nahe steht. Auch die in freier Luft inducierte Aktivität befolgt dasselbe Gesetz der Abnahme.

Die Ergebnisse sind mit der Annahme verträglich, dass ein primär aktiver Stoff in den Gesteinen der Erdoberfläche allgemein verbreitet ist, wenn auch nur in äusserst geringer Menge. So lange ein Gestein chemisch intakt ist, vermag die von jenem Stoff ausgehende Emanation nicht auszutreten, erst die verwitterte Substanz, gleichsam aufgeschlossen durch die Einwirkung des Wassers und der Luft, giebt α-Strahlen und Emanation aus. Die letztere häuft sich in den Capillaren des Erdbodens an, löst sich im Grundwasser auf und verbreitet sich durch Diffusion in die Atmosphäre.

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4. *Cosmical Radio-activity.* *By* Professor Arthur Schuster, *F.R.S.*

The fact that every physical property hitherto discovered in one element has always been found to be shared by all suggests the possibility that radio-activity may be a common property of all matter. If that is the case the so-called radio-active bodies may only be distinguished from others—like iron in the case of magnetism—by the enormously exaggerated form in which they possess the property. The apparently inactive metals may possess radio-activity, but to so small a degree that our powers of observation are insufficient to detect it. But the question arises whether in that case the effect is cumulative and should appear in the large cosmic aggregations of matter.

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There is indeed at first sight some analogy both in the case of the sun and of the earth between the effects observed in their immediate surroundings and those noticed in the neighbourhood of radio-active bodies. The earth we know must be charged with negative electricity, and attention had already for some time been drawn to the fact that this charge must constantly be renewed, as the leakage due to the spraying of ocean waves and the hot gases escaping from every chimney would ultimately dissipate the charge. But the normal electric conductivity of the air has only recently been measured, and, according to Elster and Geitel, is, under normal conditions, such that a body loses about 1¼ per cent. of its charge per minute. If the air in the immediate neighbourhood of the ground has this conductivity (which is not quite certain) the earth would lose about half its charge in an hour.

We are living therefore—and there can be little doubt about the point—in an electric field through which negatively charged particles are constantly driven outwards (kathode rays), and which possesses an electric conductivity similar to that found in the neighbourhood of radio-active bodies. The radio-activity of air rising out of the ground or of water drawn out of wells may be the consequence of emanations from a radio-active earth.

The similarity of the rays of the solar corona to kathode rays has often been pointed out, and I have maintained for a long time now that the assumption of a greater conductivity of space at times of maximum sun-spots furnishes a simple explanation of the connection between sun-spots and terrestrial magnetism. The sun, therefore, like the earth, must be taken to discharge rays which seem to possess all properties of kathode rays.[1]

The analogies I have pointed out are not complete, and may be found to be false; but we must, I think, keep our mind open to the possibility of a collective radio-activity of matter which becomes apparent in celestial bodies.

The continuous discharge of negative electricity from the earth renders it necessary to find a cause leading to a continuous renewal, and it is extremely difficult to see what that cause can be.

Though it is not directly connected with the subject under discussion, I may in conclusion digress by recalling an old discussion on the cause of gravity. Lesage's explanation involved the presence of 'corpuscles,' such as are now believed to exist by some physicists. Maxwell's objection to Lesage's explanation, which at the time seemed fatal, was that gravitation ought to be, but is not, accompanied by a rise in temperature. Whatever we may think of the explanation on other grounds, this particular objection would seem to lose its weight at present, when, in the case of one body, at any rate, a rise in temperature above that of its surroundings has actually been discovered, and when it is considered that the energy which in one case accumulates as heat may in other cases be dissipated through other channels.

5. *Intensification of Chemical Action by the Emanations from Gold and Platinum.* *By* G. T. Beilby.

When a piece of gold or platinum foil is heated on a glass slip in an atmosphere containing the products of combustion of coal gas, a halo is formed on the glass surface surrounding the foil. This halo does not to any considerable extent consist of metallic particles, but is chiefly made up of the products of decomposition of the glass. If the halo is breathed on, the slight condensation of moisture on the surface dissolves the soluble salts, and sets free silica or an insoluble silicate in the form of thin films and spicules. When the water has evaporated a crystalline deposit is left on the surface.

By prolonged heating in the above atmosphere the whole of the exposed

[1] The slight diminution of temperature at times of maximum sun-spots, which seems to be indicated by recent discussion of thermometer readings, may be a result of the increased absorption in space which we must expect to be caused by the presence of a sufficient number of electrons.

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surface of the glass slip is slightly attacked, but the intensity of this attack is not to be compared with that which occurs in the near neighbourhood of the metal. The chemical action to which the formation of the halo is due is, therefore, directly influenced by the presence of the hot metal.

It was at first thought that the metal foil might be acting simply by arresting radiant heat in its passage through the transparent glass, and thereby localising its effects; but this view is not supported by the subsequent experiments.

A number of experiments were made before it was sufficiently realised that a fairly free circulation of the atmosphere surrounding the metal is necessary if well-marked halos are to be produced. It was also found that the partial exclusion of the products of combustion from the air bath adversely affected the formation of halos.

When the glass slip with the metal foil is covered by another slip which is in contact with the metal, the halo is reduced to a sharp narrow outline of the foil.

If the cover-slip is supported just out of contact with the metal, the halo is still a sharp outline, but now an image of the foil, less sharp, but also in outline, is formed on the under surface of the cover-slip. As the distance between the cover-slip and the foil is increased the halo widens and the image on the cover-slip becomes a smooth patch without sharp outlines. These effects are obviously influenced by the more or less ample supply of the active constituents of the atmosphere which results from the greater or less freedom of circulation. This, in turn, is affected by the nearness of the cover-slip to the metal.

A piece of platinum foil, 7 millimetres square, was used in a series of experiments in which the distances of the upper slip from the metal were 0·2 mm., 1·5 mm., 3 mm., and 7 mm.; an experiment was also made in which no cover-slip was used. The temperature employed was about 500°, and the time of heating 30 minutes. At 0·2 mm. distance halo [1] and image were both in outline. At 1·5 mm. the halo was a band round the foil about 1 mm. wide; the image showed no outline, but was in size and form similar to the foil. At 3 mm. the halo had widened to over 2 mm., part of this being got by encroaching on the area covered by the foil; the image was now circular, its diameter being equal to the diagonal of the square of the foil. At 7 mm. the halo had widened to 3 to 4 mm. on three sides, and to 8 mm. on the fourth side; its general form was oval. The image was of the same form, and only a little smaller. It was evident in this case that the stream of emanations from the platinum had drifted across the slip under the influence of a current in the atmosphere of the air-bath. This evidence of drifting of the stream of emanations at once disposes of the idea that the formation of the halo and image is due in any way to the radiation or reflection of heat by the metal foil. The forms and dimensions of the halos and images strongly suggest that the emanations from the platinum are thrown upwards like a fountain, which spreads, and descends on and around the foil. When the cover-slip is at the maximum distance, it is struck by the apex of the stream, and a large but faintly defined image is produced. When the distance of the cover-slip is small, the stream is intercepted before it has spread much and the halo and image are small and well defined.

The decomposition of glass in the neighbourhood of hot metals appears to be a case of accelerated or intensified chemical action, induced by the energy of the particles shot out from the hot metal. It occurred to me that some of the cases of catalytic action by platinum and other substances might be accounted for by the existence of active emanations surrounding the catalyte, and not merely by the actual contact of the molecules of the re-agents with its surface. Experiments are now in progress to test this question.

[1] Throughout this Paper the term 'halo' is applied to the effect produced on the lower slip, on which the metal lay, and 'image' to that on the under surface of the cover-slip.

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FRIDAY, SEPTEMBER 11.

SUB-SECTION—ASTRONOMY AND METEOROLOGY.

CHAIRMAN: W. N. SHAW, Sc.D., F.R.S.

The Chairman delivered the following Address:—

Methods of Meteorological Investigation.

In opening the proceedings of the Sub-section devoted to Cosmical Physics, which we may take to be the application of the methods and results of Mathematics and Physics to problems suggested by observations of the earth, the air, or the sky, I desire permission to call your attention to some points of general interest in connexion with that department which deals with the air. My justification for doing so is that this is the first occasion upon which a position in any way similar to that which I am now called upon to fill has been occupied by one whose primary obligations are meteorological. That honour I may with confidence attribute to the desire of the Council of the Association to recognise the subject so admirably represented by the distinguished men of science who have come across the seas to deliberate upon those meteorological questions which are the common concern of all nations, and whom we are specially glad to welcome as members of this Sub-section. Their presence and their scientific work are proof, if proof is required, that meteorologists cannot regard meteorological problems as dissociable from Section A; that the prosecution of meteorological research is by the study of the kinematics, the mechanics, the physics, or the mathematics of the data compiled by laborious observation of the earth's atmosphere.

But this is not the first occasion upon which the Address from the Chair of the Sub-section has been devoted to Meteorology. Many of you will recollect the trenchant manner in which a university professor, himself a meteorologist, an astronomer, a physicist, and a mathematician, dealt candidly with the present position of Meteorology. After that Address I am conscious that I have no claim to be called a meteorologist according to the scientific standard of Section A. Professor Schuster has explained—and I cannot deny it—that the responsible duty of an office from which I cannot dissociate myself is signing weather reports; and I could wish that the duty of making the next Address had been intrusted to one of my colleagues from across the sea. But as Professor Schuster has set forth the aspect of official meteorology as seen from the academic standpoint with a frankness and candour which I think worthy of imitation, I shall endeavour to put before you the aspect which the relation between Meteorology and academic science wears from the point of view of an official meteorologist whose experience is not long enough to have hardened into that most comfortable of all states of mind, a pessimistic contentment.

Meteorology occupies a peculiar position in this country. From the point of view of Mathematics and Physics, the problems which the subject presents are not devoid of interest, nor are they free from that difficulty which should stimulate scientific effort in academic minds. They afford a most ample field for the display of trained intellect, and even of genius, in devising and applying theoretical and experimental methods. And can we say that the work is unimportant? Look where you will over the countries which the British Association may be supposed to represent, either directly or indirectly, and say where a more satisfactory knowledge of the laws governing the weather would be unimportant from any point of view. Will you take the British Isles on the eastern shores of the Atlantic, the great meteorological laboratory of the world, with the far-reaching interests of their carrying trade; or India, where the phenomena of the monsoon show most conspicuously the effects of the irregular distribution of land, the second great meteorological cause, and where recurring famines still overstrain the resources of administration. Take the Australasian colonies and the Cape, which, with the Argentine Republic, where Mr. Davis is developing so admirably

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the methods of the Weather Bureau, constitute the only land projections into the great southern ocean, the region of 'planetary meteorology'; Australia, with its periods of paralysing drought; the Cape, where the adjustment of crops to climate is a question of the hour; or take Canada, which owns at the same time a granary of enormous dimensions and a large portion of the Arctic Circle; or take the scattered islets of the Atlantic and Pacific or the shipping that goes wherever ships can go. The merest glance will show that we stand to gain more by scientific knowledge, and lose more by unscientific ignorance of the weather, than any other country. The annual loss on account of the weather would work out at no inconsiderable sum per head of the population, and the merest fraction of success in the prevention of what science must regard as preventible loss would compensate for half a century of expenditure on meteorological offices. Or take a less selfish view and consider for a moment our responsibilities to the general community of nations, the advantages we possess as occupying the most important posts of observation. If the meteorology of the world were placed, as perhaps it ought to be, in the hands of an International Commission, it can be no exaggeration to say that a considerable majority of the selected sites for stations of observation would be on British soil or British ships. We cannot help being the most important agency for promoting or for obstructing the extension of meteorological science. I say this bluntly and perhaps crudely because I feel sure that ideas not dissimilar from these must occasionally suggest themselves to every meteorologist, British or foreign; and if they are to be expressed—and I think you will agree with me that they ought to be—a British meteorologist ought to take the responsibility of expressing them.

And how does our academic organisation help us in this matter of more than parochial or even national importance? There was a time when Meteorology was a recognised member of the large physical family and shared the paternal affection of all professors of Physics; but when the poor nestling began to grow up and develop some individuality electricity developed simultaneously with the speed of a young cuckoo. The professors of Physics soon recognised that the nest was not large enough for both, and with a unanimity which is the more remarkable because in some of these academic circles utilitarianism is not a condition of existence, and pure science, not market value, might be the dominant consideration—with singular unanimity the science which bears in its left hand, if not in its right, sources of wealth beyond the dreams of avarice was recognised as a veritable Isaac, and the science wherein the fruits of discovery must be free for all the world, and in which there is not even the most distant prospect of making a fortune—that science was ejected as an Ishmael. Electrical engineering has an abundance of academic representatives; brewing has its professorship and its corps of students, but the specialised physics of the atmosphere has ceased to share the academic hospitality. So far as I know the British universities are unanimous in dissembling their love for Meteorology as a science, and if they do not actually kick it downstairs they are at least content that it has no encouragement to go up. In none is there a professorship, a lectureship, or even a scholarship, to help to form the nucleus of that corps of students which may be regarded as the primary condition of scientific development.

Having cut the knot of their difficulties in this very human but not very humane method, the universities are, I think, disposed to adopt a method of justification which is not unusual in such cases; indications are not wanting which disclose an opinion that Meteorology is, after all, not a science. There are, I am aware, some notable exceptions; but do I exaggerate if I say that when university professors are kind enough to take an interest in the labours of meteorologists, who are doing their best amid many discouragements, it is generally to point out that their work is on the wrong lines; that they had better give it up and do something else? And the interest which the universities display in a general way is a good-humoured jest about the futility of weather prophecy, and the kindly suggestion that the improvement in the prediction of the next twenty-four hours' weather is a natural limit to the orbit of an Ishmaelite's ambition.

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Under these circumstances such an Address as Professor Schuster's is very welcome: it recognises at least a scientific brotherhood and points to the responsibility for a scientific standard; it even displays some of the characteristics of the Good Samaritan, for it offers his own beast on which to ride, though it recommends the unfortunate traveller to dispose of what little clothing the stripping has left to provide the two pence for the host.

It is quite possible that the unformulated opinion of the vast majority of people in this country who are only too familiar with the meteorological vagaries of the British Isles is that the weather does just as it pleases; that any day of the year may give you an August storm or a January summer's day; that there are no laws to be discovered, and that the further prosecution of so unsatisfactory a study is not worth the time and money already spent upon it. They forget that there are countries where, to judge by their languages, the weather has so nearly the regularity of 'old time' that one word is sufficient to do duty for both ideas. They forget that our interests extend to many climates, and that the characteristics of the eastern shores of the North Atlantic are not appropriate to, say, western Tropical Africa. That may be a sufficient explanation of the attitude of the man in the street, but as regards the British universities dare I offer the difficulty of the subject as a reason for any want of encouragement? Or shall I say that the general ignorance on the part of the public of the scientific aspirations and aims of meteorologists and of the results already obtained is a reason for the universities to keep silence on the subject? With all respect I may say that the aspect which the matter presents to official meteorologists is that the universities are somewhat oblivious of their responsibilities and their opportunities.

I have no doubt that it will at once be said that Meteorology is supported by Government funds, and that alma mater must keep her maternal affection and her exiguous income for subjects that do not enjoy State support. I do not wish just now to discuss the complexities of alma mater's housekeeping. I know she does not adopt the same attitude with regard to astronomy, physics, geology, mineralogy, zoology, or botany, but let that pass. From the point of view of the advancement of science I should like to protest against the idea that the care of certain branches of science by the State and by the universities can be regarded as alternative. The advancement of science demands the co-operation of both in their appropriate ways. As regards Meteorology, in my experience, which I acknowledge is limited, the general attitude towards the department seems to be dictated by the consideration that it must be left severely alone in order to avoid the vicious precedent of doing what is, or perhaps what is thought to be, Government work without getting Government pay, and the result is an almost monastic isolation.

There is too much isolation of scientific agencies in this country. You have recently established a National Physical Laboratory, the breath of whose life is its association with the working world of physics and engineering, and you have put it—where? At Cambridge, or anywhere else where young physicists and engineers are being trained? No; but in the peaceful seclusion of a palace in the country, almost equidistant, academically speaking, from Cambridge, Oxford, London, and everywhere else. You have established a Meteorological Office, and you have put it in the academic seclusion of Victoria Street. Monastic isolation may have its advantages, but I am perfectly certain it is not good for the scientific progress of Meteorology. How can one hope for effective scientific development without some intimate association with the institutions of the country, which stand for intellectual development and the progress of science?

I could imagine an organisation which by association of the universities with a central office would enable this country, with its colonies and dependencies, to build up a system of meteorological investigation worthy of its unexampled opportunities. But the co-operation must be real and not one-sided. Meteorology, which depends upon the combination of observations of various kinds from all parts of the world, must be international, and a Government department in some form or other is indispensable. No university could do the work. But whatever form Government service takes it will always have some of those characteristics which, from the point of view of research, may be called bondage.

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On the other hand, research, to be productive, must be free with an academic freedom, free to succeed or fail, free to be remunerative or unremunerative, without regard to Government audits or House of Commons control. Research looks to the judgment of posterity with a faith which is not unworthy of the Churches, and which is not among those excellent moral qualities embodied in the Controller and Auditor General. *Die academische Freiheit* is not the characteristic of a Government department. The opportunity which gave to the world the 'Philosophiæ Naturalis Principia' was not due to the State subvention of the Deputy Mastership of the Mint, but to the modest provision of a professorship by one Henry Lucas, of whose pious benefaction Cambridge has made such wonderful use in her Lucasian professors.

The future of Meteorology lies, I believe, in the association of the universities with a central department. I could imagine that Liverpool or Glasgow might take a special interest in the meteorology of the sea; they might even find the means of maintaining a floating observatory; and when I say that we know practically nothing of the distribution of rainfall over the sea, and we want to know everything about the air above the sea, you will agree with me that there is room for such an enterprise. Edinburgh might, from its association with Ben Nevis, be desirous of developing the investigation of the upper air over our land; in Cambridge might be found the author of a book, on the principles of atmospheric physics, worthy of its Latin predecessor; and for London I can assign no limited possibilities.

If such an association were established I should not need to reply to Professor Schuster's suggestion for the suppression of observations. The real requirement of the time is not fewer observations, but more men and women to interpret them. I have no doubt that the first expression of such an organisation would be one of recognition and acknowledgment of the patience, the care, the skill, and the public spirit—all of them sound scientific characteristics—which furnish at their own expense those multitudes of observations. The accumulated readings appal by their volume, it is true, but they are, and must be, the foundation upon which the scientific structure will be built.

So far as this country is concerned when one puts what is in comparison with what might be it must be acknowledged that the tendency to pessimistic complaisance is very strong. Yet I ought not to allow the reflections to which my predecessor's Address naturally give rise to be too depressing. I should remember that, as Dr. Hellmann said some years ago, Meteorology has no frontiers, and each step in its progress is the result of efforts of various kinds in many countries, our own not excluded. In the presence of our guests to-day, some of whom know by practical experience the advantages of the association of academic liberty with official routine, remembering the recent conspicuous successes in the investigation of the upper air in France, Germany, Austria, Russia, and the United States, and the prospect of fruitful co-operation of meteorology with other branches of cosmical physics, I may well recall the words of Clough:

> Say not, the struggle nought availeth . . .
> And as things have been, they remain.
>
> If hopes were dupes, fears may be liars;
> It may be, in yon smoke concealed
> Your comrades chase e'en now the fliers,
> And, but for you, possess one field.
>
> For while the tired waves, vainly breaking,
> Seem here no painful inch to gain,
> Far back, through creeks and inlets making,
> Comes silent, flooding in, the main.
>
> And not by eastern windows only,
> When daylight comes, comes in the light;
> In front, the sun climbs slow, how slowly,
> But westward, look, the land is bright.

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Official meteorologists are not wanting in scientific ambitions and achievements. It is true that Professor Hann, whose presence here would have been so cordially welcomed, left the public service of Austria to continue his services to the world of science by the compilation of his great handbook, and Snellen is leaving the direction of the weather service of the Netherlands for the more exclusively scientific work of directing an observatory of terrestrial physics; but I am reminded by the presence of Professor Mascart of those services to meteorological optics and terrestrial magnetism that make his place as President of the International Committee so natural and fitting; and of the solid work of Angot on the diurnal variation of the barometer and the reduction of barometric observations for height that form conspicuous features among the many valuable memoirs of the Central Bureau of Paris.

Of the monumental work of Hildebrandsson in association with Teisserenc de Bort on clouds, which culminated quite recently in a most important addition to the pure kinematics of the atmosphere, I hope the authors will themselves speak. Professor Willis Moore's presence recalls the advances which Bigelow has made in the kinematics and mechanics of the atmosphere under the auspices of Professor Moore's office, and reminds us of the debt of gratitude which the English-speaking world owes to Professor Cleveland Abbé, of the same office, for his treatment of the literature of atmospheric mechanics.

If General Rykatcheff had only the magnificent climatological Atlas of the Russian Empire to his credit he might well rest satisfied. Professor Mohn's contributions to the mechanics of the atmosphere are examples of Norwegian enterprise in the difficult problems of Meteorology, while Dr. Paulsen maintains for us the right of meteorologists to share in the results of the newest discoveries in physics. Davis's enterprise in the far south does much to bring the southern hemisphere within our reach, while Chaves places the meteorology of the mid-Atlantic at the service of the scientific world. Need I say anything of Billwiller's work upon the special effect of mountains upon meteorological conditions, or of the immense services of those who cooperate with Hann in the production of the 'Meteorologische Zeitschrift,' Professor Pernter, of Vienna, and Dr. Hellmann, of Berlin; of Palazzo's contributions to terrestrial magnetism? The mention of Eliot's Indian work, or of Russell's organisation of Australian meteorology, will be sufficient to show that the dependencies and colonies are prepared to take a share in scientific enterprise. And if I wished to reassure myself that even the official meteorology of this country is not without its scientific ambitions and achievements I would refer not only to Scott's many services to science but also to Strachey's papers on Indian and British Meteorology and to the official contributions to Marine Meteorology.

There is another name, well known in the annals of the British Association, that will for ever retain an honoured place among the pioneers of meteorological enterprise—that of James Glaisher, the intrepid explorer of the upper air, the Nestor of official meteorologists, who has passed away since the last meeting of the Association.

I should like especially to mention Professor Hergesell's achievements in the organisation of the international investigation of the upper air by balloons and kites, because it is one of the departments which offers a most promising field for the future, and in which we in this country have a good many arrears to make up. I hope Professor Hergesell will later on give us some account of the present position of that investigation, and I am glad that Mr. Rotch, to whose enterprise the development of what I may call the scientific kite industry is largely due, is present to take part in the discussion.

Yet with all these achievements it must be confessed that the progress made with the problems of general or dynamical Meteorology in the last thirty years has been disappointing. When we compare the position of the subject with that of other branches of Physics it must be allowed that it still lacks what astronomy found in Newton, sound in Newton and Chladni, light in Young or Fresnel, heat in Joule, Kelvin, Clausius, and Helmholtz, and electricity in Faraday and Maxwell. Above all, it lacks its Kepler. Let me make this clear. Kepler's contribution to physical astronomy was to formulate laws which no heavenly body

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actually obeys, but which enabled Newton to deduce the law of gravitation. The first great step in the development of any physical science is to substitute for the indescribably complex reality of nature an ideal system that is an effective equivalent for the purposes of theoretical computation. I cannot refrain from quoting again from Plato's 'Republic' a passage which I have quoted elsewhere before. It expresses paradoxically but still clearly the relation of natural philosophy to natural science. In the discussion of the proper means of studying sciences Socrates is made to say, 'We shall pursue astronomy with the help of problems just as we pursue geometry; but we shall let the heavenly bodies alone if it is our design to become really acquainted with astronomy.' What I take to be the same idea is expressed in other words by Rayleigh in the introduction to his 'Sound.' He there points out as an example that the natural problem of a sounding tuning-fork really comprises the motion of the fork, the air, and the vibrating parts of the ear; and the first step in sound is to simplify the complex system of nature by assuming that the vibrations of the fork, the air, and the ear can be treated independently. In many sciences this step is a most difficult one to take. What student of nature, contemplating the infinity of heavenly bodies and unfamiliar with this method of idealism, would imagine that the most remarkable and universal generalisation in physical science was arrived at by reducing the dynamics of the universe to the problem of three bodies? When we look round the sciences each has its own peculiar ideals and its own physical quantities: astronomy has its orbits and its momentum, sound its longitudinal vibration, light its transverse vibration, heat its energy and entropy, electricity its 'quantity' and its wave, but meteorology has not yet found a satisfactory ideal problem to substitute for the complexity of nature. I wish to consider the aspect of the science from this point of view and to recall some of the attempts made to arrive at a satisfactory modification of reality. I do not wish to refer to such special applications of physical reasoning as may be involved in the formation of cloud, the thermodynamics of a mixture of air and water vapour, the explanation of optical or electrical phenomena, nor even Helmholtz's application of the theory of gravitational waves to superposed layers of air of different density. These require only conventions which belong already to physics, and though they may furnish suggestions they do not themselves constitute a general meteorological theory.

The most direct efforts to create a general theory of atmospheric circulation are those which attempt to apply Newtonian dynamics, with its more recent developments on the lines of hydrodynamics and thermodynamics. Attempts have been made, mathematical or otherwise, to determine the general circulation of the atmosphere by the application of some form of calculation, assuming only the sun and a rotating earth, with an atmosphere, as the data of the problem. I confess that these attempts, interesting and ingenious as they are, seem to me to be somewhat premature. The 'problem' is not sufficiently formulated. When Newton set to work to connect the motions of the heavenly bodies with their causes, he knew what the motions of the heavenly bodies were. Mathematics is an excellent engine for explaining and confirming what you know. It is very rarely a substitute for observation, and before we rely upon it for telling us what the nature of the general circulation of the atmosphere really is, it would be desirable to find out by observation or experiment what dynamical and elastic properties must be attributed to an extremely thin sheet of compressible fluid rotating about an axis with a velocity reaching 1,000 miles an hour, and subject to periodic heating and cooling of a very complicated character. It would be more in consonance with the practice of other sciences to find out by observation what the general circulation is before using mathematics to explain it. What strikes one most about the mathematical treatises on the general circulation of the atmosphere is that what is true about the conclusions is what was previously known from observation. It is, I think, clear that that method has not given us the working ideal upon which to base our theory.

Consider next the attempts to regard atmospheric phenomena as periodic. Let me include with this the correlation of groups of atmospheric phenomena with each other or with those of the sun, when the periodicity is not necessarily regular, and

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the scientific process consists in identifying corresponding changes. This method has given some remarkable results by the comparison of the sequence of changes in the meteorological elements in the hands of Pettersen and Meinardus, and by the comparison of the variation of pressure in different parts of the globe by Sir Norman Lockyer and Dr. W. J. S. Lockyer; as regards the earth and the sun the subject has reached the stage of productive discussion. As a matter of fact, by continuing this Address I am preventing Sir Norman Lockyer from telling you all about it.

For the purpose of dealing with periodicity in any form we substitute for nature an ideal system obtained by using mean values instead of individual values, and leaving out what, from this point of view, are called accidental elements. The simplification is perfectly legitimate. Passing on to the consideration of periodicity in the stricter sense the process which has been so effective in dealing with tides, the motions of the liquid layer, is very attractive as a means of attacking the problems of the atmosphere, because, in accordance with a principle in dynamics, to every periodic cause there must correspond an effect of the same period, although the relation of the magnitude of the effect to the cause is governed by the approximation of the natural period of the body to that of the cause.

There are two forms of the strict periodic method. One is to examine the generalised observations for periodicities of known length, whether it be that of the lunar rotations or of sunspot frequency, or of some longer or shorter period. In this connexion let me acknowledge a further obligation to Professor Schuster for tacking on to his Address of last year a development of his work on the detection of hidden periodicities by giving us a means of estimating numerically what I may call the reality of the periodicity. The other method is by harmonic analysis of a series of observations with the view of finding causes for the several harmonic components. I may say that the Meteorological Office, supported by the strong opinion of Lord Kelvin, has favoured that plan, and on that account has for many years issued the hourly results for its observatories in the form of five-day means as representing the smallest interval for which the harmonic analysis could be satisfactorily employed. Sir Richard Strachey has given some examples of its application, and the capabilities of the method are by no means exhausted, but as regards the general problem of dynamic meteorology harmonic analysis has not as yet led to the disclosure of the required generalisation.

I ought to mention here that Professor Karl Pearson, with the assistance of Miss Cave, has been making a most vigorous attempt to estimate the numerical value of the relationship, direct or inverse, between the barometric readings at different places on the earth's surface. The attempt is a most interesting one as an entirely new departure in the direction of reducing the complexity of atmospheric phenomena. If it were possible to find coordinates which showed a satisfactory correlation it might be possible to reduce the number of independent variables and refer the atmospheric changes to the variations of definite centres of action in a way that has already been approached by Teisserenc de Bort and Hildebrandsson from the meteorological side.

Years ago, when Buys Ballot laid down as a first law of atmospheric motion that the direction of the wind was transverse to the barometric gradient and the force largely dependent upon the gradient, and when the examination of synchronous charts showed that the motion of air could be classified into cyclonic and anticyclonic rotation, it appeared that the meteorological Kepler was at hand, and the first step towards the identification of a working meteorological unit had been taken—the phenomena of weather might be accounted for by the motion and action of the cyclonic depression, the position of the ascending current, the barometric minimum. The individual readings over the area of the depression could be represented by a single symbol. By attributing certain weather conditions to certain parts of the cyclonic area and supposing that the depression travelled with more or less unchanged characteristics the vagaries of weather changes can be accounted for. For thirty years or more the depression has been closely watched, and thousands of successful forecasts have been based upon a knowledge of its

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habits. But unfortunately the travelling depression cannot be said to preserve its identity in any sense to which quantitative reasoning can be applied. As long as we confine ourselves to a comparatively small region of the earth's surface the travelling depression is a real entity, but when we widen our area it is subject to such variations of path, of speed, of intensity, and of area that its use as a meteorological unit is seriously impaired, and when we attempt to trace it to its source or follow it to its end it eludes us. Its origin, its behaviour, and its end are almost as capricious as the weather itself.

Nor if we examine other cases in which a veritable entity is transmitted can we expect that the simple barometric distribution should be free from inexplicable variations. We are familiar with ordinary motion, or, as I will call it, astronomical motion, wave motion, and vortex motion. Astronomical motion is the motion of matter, wave motion the motion of energy, vortex motion the motion of matter with energy, but the motion of a depression is merely the transmission of the locus of transformation of energy; neither the matter nor the energy need accompany the depression in its motion. If other kinds of motion are subject to the laws of conservation of matter and conservation of energy, the motion of the depression must have regard also to the law of dissipation of energy. An atmospheric disturbance, with the production of rainfall and other thermal phenomena, must comply in some way with the condition of maximum entropy, and we cannot expect to account for its behaviour until we can have proper regard to the variations of entropy. But the conditions are not yet in a form suitable for mathematical calculation, and we have no simple rules to guide us. So far as Meteorology is concerned, Willard Gibbs unfortunately left his work unfinished.

When the cyclonic depression was reluctantly recognised as too unstable a creature to carry the structure of a general theory Mr. Galton's anticyclones, the areas of high pressure and descending currents, claimed consideration as being more permanent. Professors Köppen and van Bebber have watched their behaviour with the utmost assiduity and sought to find therein a unit by which the atmospheric changes can be classified; but I am afraid that even Dr. van Bebber must allow that his success is statistical and not dynamical. 'High pressures' follow laws on the average, and the quantity we seek is not an average but an individual.

The question arises, whether the knowledge of the sequence of weather changes must elude us altogether, or will yield to further search. Is the man in the street right after all? But consider how limited our real knowledge of the facts of atmospheric phenomena really is. It may very well be that observations on the surface will never tell us enough to establish a meteorological entity that will be subject to mathematical treatment; it may be that we can only acquire a knowledge of the general circulation of the atmosphere by the study of the upper air, and must wait until Professor Hergesell has carried his international organisation so far that we can form some working idea therefrom of general meteorological processes. But let us consider whether we have even attempted for surface meteorology what the patience of astronomers from Copernicus to Kepler did for astronomy.

Do we yet fully comprehend the kinematics of the travelling depression; and if not, are we in a satisfactory position for dealing with its dynamics? I have lately examined minutely the kinematics of a travelling storm, and the results have certainly surprised me and have made it clear that the travelling depressions are not all of one kinematical type. We are at present hampered by the want of really satisfactory self-recording instruments. I have sometimes thought of appealing to my friends the professors of physics who have laboratories where the reading of the barometer to the thousandth of an inch belongs to the work of the 'elementary class,' and of asking them to arrange for an occasional orgy of simultaneous readings of the barometer all over the country with corresponding weather observations for twenty-four consecutive hours, so that we might really know the relation between pressure, rainfall, and temperature of the travelling depressions; but I fear the area covered would even then hardly be large enough, and we must improve our self-recording instruments.

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Then, again, have we arrived at the extremity of our knowledge of the surface circulation of the atmosphere? We know a great deal about the average monthly distribution, but we know little about the instantaneous distribution. It may be that by taking averages we are hiding the very points which we want to disclose.

Let me remind you again that the thickness of the atmosphere in proportion to the earth's surface is not unsatisfactorily represented by a sheet of paper. Now it is obvious that currents of air in such a thin layer must react upon each other horizontally, and therefore we cannot *à priori* regard one part of the area of the earth's surface as meteorologically independent of any other part. We have daily synoptic charts for various small parts of the globe, and the Weather Bureau extended these over the northern hemisphere for the years 1875 to 1879; but who can say that the meteorology of the northern hemisphere is independent of that of the southern? To settle that primary question we want a synchronous chart for the globe. As long as we are unable to watch the changes in the globe we are to a certain extent groping in the dark. A great part of the world is already mapped every day, and the time has now arrived when it is worth while to consider what contributions we can make towards identifying the distribution of pressure over the globe. We may idealise a little by disregarding the local peculiarities without sacrificing the general application. I have put in the exhibition a series of maps showing what approximation can be made to an isochronous chart of the globe without special effort. We are gradually extending the possibility of acquiring a knowledge of the facts in that as in other directions. With a little additional enterprise a serviceable map could be compiled; and when that has been reached, and when we have added to that what the clouds can tell us, and when the work of the Aëronautical Committee has so far progressed that we can connect the motion of the upper atmosphere with the conditions at the surface, when we know the real kinematics of the vertical and horizontal motion of the various parts of a travelling storm, we shall, if the universities will help us, be able to give some rational explanation of those periodic relations which our solar physics friends are identifying for us, and to classify our phenomena in a way that the inheritors of Kepler's achievements associated with us in this Section may be not unwilling to recognise as scientific.

The following Papers were read:—

1. *On Simultaneous Solar and Terrestrial Phenomena.*[1]
By Sir N. Lockyer, *F.R.S.*

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2. *On the Relation of the Rainfall of Scotland to the Sun-spot Periods, 1855–98.* *By* A. Buchan, *M.A., LL.D., F.R.S., F.R.S.E.*

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3. *Etudes sur les Dépressions Barométriques à Diverses Hauteurs.*
Par L. Teisserenc de Bort.

Il y a dix-sept années maintenant que j'ai montré pour la première fois que lorsqu'on construit la carte des isobares moyennes des différents mois à diverses altitudes, en partant des pressions et de la température au sol, on voit s'effacer la plupart des maxima et minima de pression. Ces aires entourées de courbes fermées font place à de simples inflexions des isobares qui se disposent en pente depuis les régions tropicales jusque vers les régions polaires.

Si l'on considère par exemple la carte moyenne des isobares de janvier on voit que les grandes aires de haute pressions de Sibérie et de l'Amérique du Nord, qui commandent la circulation sur la plus grande partie des continents, sont déjà très amoindries à l'altitude de 2 et disparaissent à peu près complètement à 4,000 m.

[1] Printed as an Appendix to the Report of the Southport Meeting of the International Meteorological Committee.

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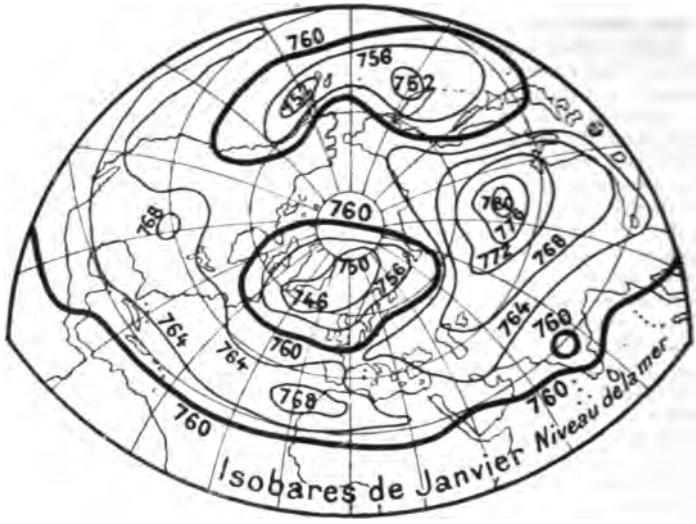
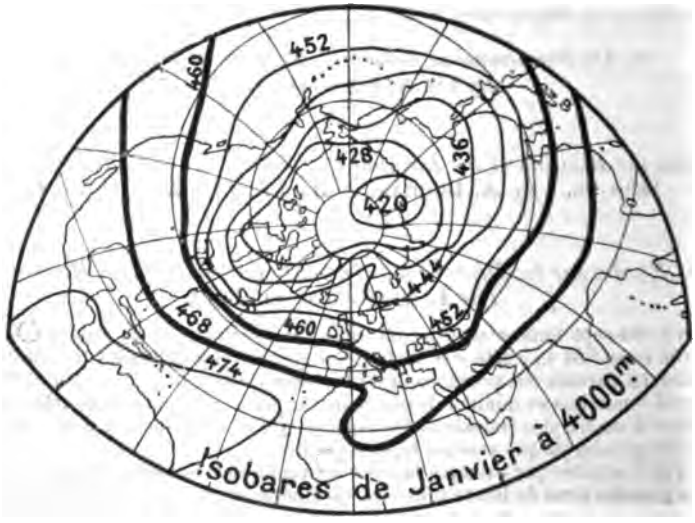
Le minimum barométrique des Océans Atlantique et Pacifique Nord est reporté plus au nord en même temps qu'il s'étend à droite et à gauche de façon à former



son plus une aire limitée en longitude mais une simple zone de basse pression entourant la terre entière.

Mais la construction de ces diverses cartes supposait que la formule barométrique qu'on emploie est bien applicable et qu'on connait assez exactement la décroissance de température avec l'altitude aux divers points.



L'exactitude de la formule employée, outre qu'elle était déjà vérifiée par les observations faites sur les montagnes, a en outre reçue une confirmation directe par

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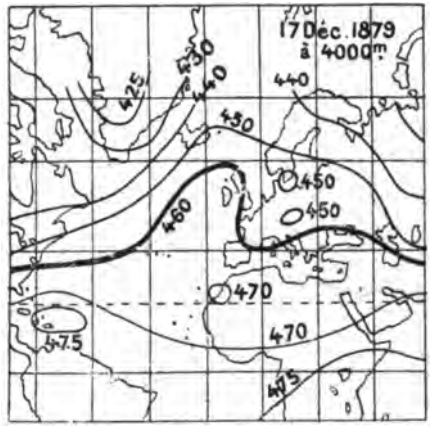
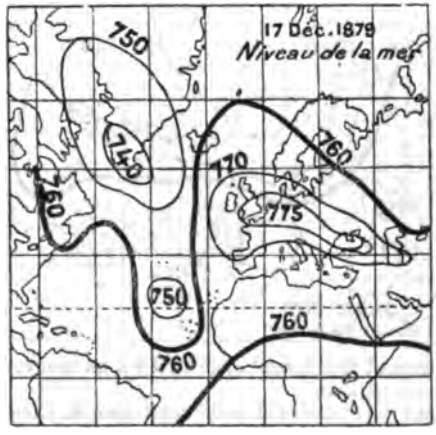
les déterminations des hauteurs d'une série de ballons sondes (lancés dans ces quatre dernières années à l'observatoire de météorologie dynamique) faites simultanément par le baromètre et par triangulation. Le ballon était visé au théodolite par deux observateurs placés aux extrémités d'une base reliées par téléphone.

La comparaison des deux méthodes a montré que les hauteurs déduites du



baromètre sont ordinairement exactes jusqu'à 8 ou 10 kil. à $\frac{1}{100}$ près. A une altitude de 4,000 kil. l'incertitude est donc négligeable.

Quant à la décroissance de la température, son influence est assez grande. Les déterminations faites en ballon, et en particulier en ballon sonde, montrent qu'elles varient ordinairement entre 0°·45 par 100 m. et 0°·90. Pour une altitude de 4,000 m., partant d'une température donnée, on obtient une température qui peut différer d'environ 8 à 9 degrés, ce qui pour la température de la couche moyenne du sol à



4,000 m. correspond à une différence de 4°·5, et introduit une incertitude d'environ 5 millimètres dans les isobares calculées pour la hauteur de 4,000 m.

Mais les sondages par ballon sonde ont montré que ces différences de décroissance sont extrêmes et qu'ordinairement les nombres calculés se rapprochent beaucoup des nombres observés.

Une fois en possession de ces résultats vérifiés par les observations des cirrus,

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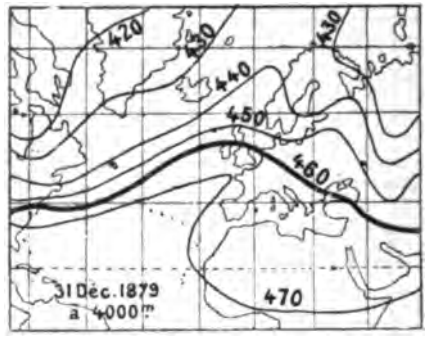
je me suis demandé si les isobares de nos cartes journalières ne seraient pas modifiées notablement à mesure qu'on s'élève dans l'atmosphère.

J'ai donc essayé de calculer les isobares dans certain nombre de cartes typiques à l'altitude de 4,000 m.

Les résultats ont été analogues à ceux obtenus pour les cartes moyennes, avec cette différence notable cependant qu'un certain nombre de minima de pression ont présenté une plus grande persistance et se retrouvent ainsi sur les cartes des isobares à 4,000 m.

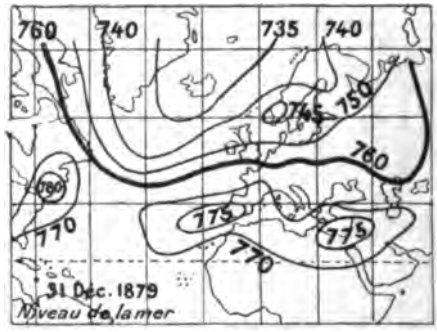
Nous donnons ici quelques exemples de ces diverses cartes.



Les vérifications directes des conclusions tirées de nos cartes se trouvent dans les observations des points d'aterrissage des ballons sondes.

Ces derniers nous montrent que les ballons lancés au S.S.E., E., non loin d'un centre de dépression, quand ils se maintiennent à une hauteur moyenne de 6 à 7 kilomètres tombent en un point situé à une latitude supérieure et la plupart du temps en des lieux où la pression est inférieure à celle du point d'où ils sont partis, *ce qui montre que la convergence de l'air vers le centre est réelle.*

Les ballons qui atteignent une assez grande altitude, 11 à 14 kil., et font un séjour de quelques heures dans les hautes couches tombent en des points situés sur



l'avant de la dépression et témoignent ainsi qu'il y a un mouvement divergent bien marqué dans les hautes régions.

Ces résultats sont bien d'accord avec ceux que M. Clément Ley et surtout M. Hildebrandsson ont mis en lumière par l'étude des mouvements des nuages. Mais ils prouvent que même dans les portions où le ciel est tout à fait couvert, et par conséquent l'observation des nuages élevés ne peut pas nous renseigner, on a surtout à l'avant une circulation convergente en bas et divergente en haut.

Vers le bord des dépressions la divergence à la région supérieure est très marquée et les ballons atteignant de hautes couches tombent en des points où le baromètre est bien plus haut qu'à leur point de départ.

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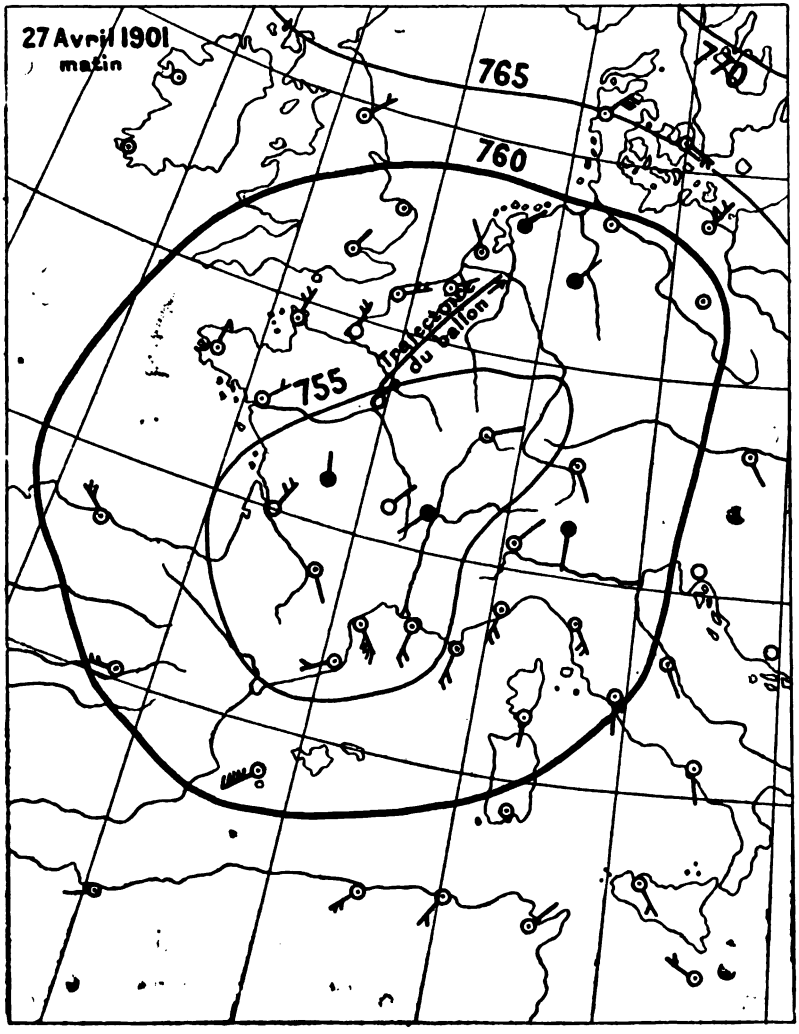
La divergence de l'air du minimum dans les hautes régions est donc très accentuée à mesure qu'on s'approche de la zone des pressions plus fortes vers lesquelles converge l'air supérieur.

Mais le fait le plus intéressant est celui que les trajectoires des ballons nous montrent dans la partie N.W. et W. des dépressions de nos régions.

Les ballons au lieu de tomber à l'ouest, au S.W. ou au sud de leur point de



départ, comme la direction générale du vent semblerait l'indiquer, tombent au nord ou au N.W., montrant ainsi clairement que le mouvement de rotation autour du centre de dépression ne se prolonge pas dans la hauteur.

Ce résultat montre que la dépression n'est pas fermée vers le nord, ce qui est bien d'accord avec ce que les cartes d'isobares calculées nous indiquent.

Mais ils montrent en *outre que le vent supérieur à l'arrière de la dépression vient du sud ou du S.W.*

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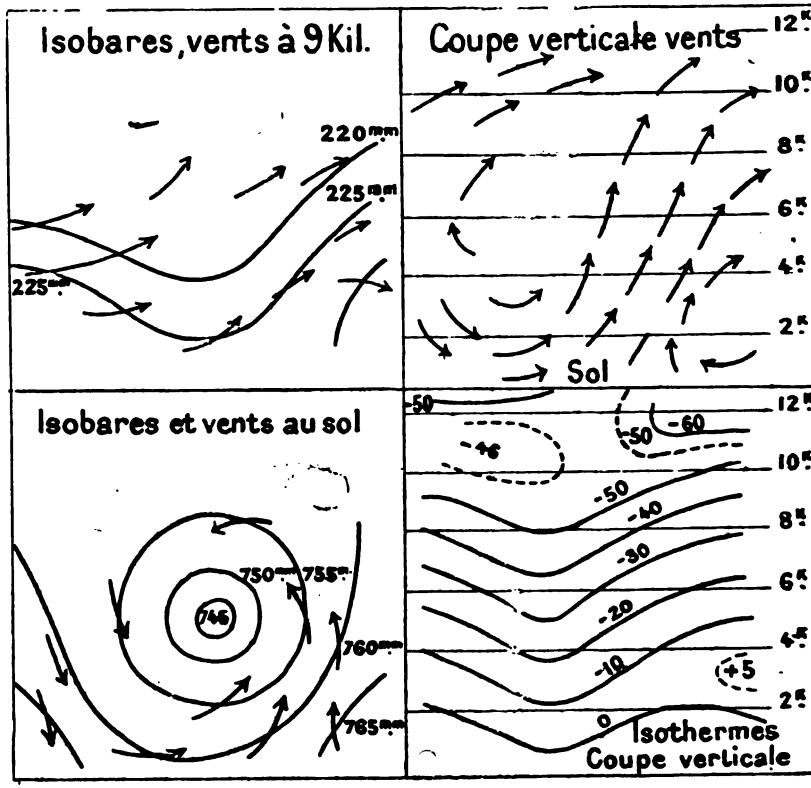
Ces conclusions ont été tout à fait confirmées par un cas où avons-nous pu suivre par des visées de deux théodolites un ballon sonde parti de l'observatoire de Trappes dans la portion N.W. d'une dépression.

Ce ballon après avoir marché avec le vent inférieur pendant un certain temps et jusqu'à une altitude de 5,000 m. s'arrêta dans son mouvement vers le S.W. pour rebrousser chemin et marcher vers le N.N.E., direction qu'il conserva ensuite pendant presque tout son parcours.

Il a aterri en Belgique.

La carte ci-jointe indique la situation générale des isobares, le matin du lancer et la trajectoire suivie par le ballon.

Les observations par ballon sonde et par cerf-volant nous renseignent d'une



manière très intéressante sur la distribution verticale des températures dans les dépressions et dans les maxima barométriques.

Le point le plus saillant et général dans les dépressions de nos régions est la rapide décroissance de température dans le corps même de la dépression jusqu'à une altitude variable, mais qui atteint ordinairement 7 kilomètres.

Le point de savoir s'il fait plus chaud ou plus froid dans la partie basse de la dépression que dans la portion correspondante du maximum barométrique n'est pas bien élucidé—il est d'ailleurs dépendant dans une large mesure de la saison et des circonstances géographiques. En hiver la partie inférieure du maximum est ordinairement plus froide, parce que le ciel est clair, le rayonnement intense et les vents continentaux. En été c'est ordinairement le contraire, la pureté du ciel déterminant un échauffement du sol par insolation, pendant que la dépression

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qui s'accompagne de temps couvert et de pluie empêche le réchauffement du sol.

Dans ce qu'on peut appeler la région d'altitude moyenne, c'est-à-dire au-dessus de 4,000 m. dans la région occupée le plus souvent par les alto-cumulus, la dépression est notablement plus froide que le maximum ; plus haut la différence tend à s'égaliser, parce qu'alors la décroissance de température devient au moins égale dans le maximum à ce qu'elle est dans le corps de la dépression.

Couches Isothermes.—Un phénomène particulier que nos observations par ballon nous ont permis de découvrir joue un rôle important dans la décroissance de température dans différentes situations.

Nos lancers faits de nuit pour nous soustraire aux erreurs provenant de l'insolation ont permis dès 1899 d'étudier la température au-dessus de 10 kilomètres jusqu'à 13 et 14 kilomètres.

Nous n'avons pas tardé à reconnaître qu'à partir d'une hauteur variable avec la situation du temps, mais ordinairement supérieure à 10 kil., la température cessait de descendre, ou même présentait une légère élévation, avec quelquefois un léger abaissement ensuite.

D'une manière générale on arrive à une couche où la température reste à peu près uniforme et que pour cela nous avons appelé la *zone isotherme*. Cette zone présente souvent une épaisseur de plusieurs milliers de mètres.

Le second fait auquel nos observations nous ont conduit c'est que la hauteur où on pénètre dans la zone isotherme varie de 8,000 à 14,000 mètres au moins.

Cette zone est la plus basse au-dessus des dépressions barométriques, et se tient d'une plus grande altitude au-dessus des maxima de pression et sur le bord avant des grandes dépressions barométriques.

Il résulte de ce fait que dans les couches élevées, au-dessus de la dépression, la température cesse de diminuer à une altitude qui est ordinairement de 10 kilomètres, pendant que la température dans les régions de hautes pressions voisines continue à diminuer pendant plusieurs kilomètres encore.

La température plus froide qui se remarque dans la dépression tend donc à s'égaliser avec celle du maximum barométrique et elle finit par devenir supérieure.

Ce dernier fait est démontré directement par la constatation que les températures les plus froides se trouvent au-dessus des régions de maxima barométriques.

En résumé après le tracé des isobares dans l'atmosphère, et d'après les mouvements des ballons et les déterminations de température faites avec ces sondages nous pouvons représenter les dépressions de nos régions sous la forme suivante :

Comme on le voit par la coupe verticale de l'atmosphère les isothermes se disposent de façon à ce que la température plus basse à l'intérieur de la dépression dans la région moyenne devienne plus haute à la partie supérieure.

Il est bien entendu dans tout ce que nous disons qu'il s'agit des dépressions et des hautes pressions de nos régions, les seules que nous ayons pu étudier par ballon et cerf-volant.

En résumé, les dépressions de nos régions nous apparaissent donc comme formées sur la pente du grand minimum barométrique (voir carte de janvier à 4,000 m.) qui a son centre vers les pôles et dont le mouvement des cirrus d'ouest à l'est, bien démontré par M. Hildebrandsson, indique toute l'activité.

L'avenir nous apprendra quelle est la nature des perturbations qui se produisent sur la pente du grand minimum, donnant naissance à nos dépressions tourbillonnaires dont les sondages sériens permettent de préciser la constitution.

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4. *The Origin and Forms of Hoar Frost.* *By* KARL GROSSMANN, *M.D., F.R.C.S., F.G.S., and* JOSEPH LOMAS, *A.R.C.S., F.G.S.*

Hoar frost is produced by the transition of aqueous vapour direct into the solid state without any noticeable intervention of the liquid state. Under these circumstances H_2O solidifies in a highly crystalline form. When solidifying from the liquid state it is only crystalloid.

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The conditions favourable for the formation of hoar frost occur so abundantly in nature that it is surprising that the forms of natural hoar frost have been until recently unknown. In 1892 one of us found the walls of an ice cave in Iceland coated with some remarkably fine hoar frost crystal, of a shape hitherto unknown, but since then found by us to be the typical and principal form of hoar frost crystals, viz., hollow hexagonal pyramids.

It was found that the most favourable conditions for the formation of large crystals are not only moist air at a low temperature, but also a quite undisturbed state of the air. For this reason the finest crystals are formed in caves or, generally speaking, in closed spaces.

With regard to the forms of hoar frost, the most typical form, as already mentioned, is a hollow hexagonal pyramid. It is built up upon a small flat hexagonal prism, which springs from a solid wall; round its edges a hexagonal step is formed; round the outer edge of this, again, another larger hexagonal step, and so forth, exactly analogous to the hollow salt hopper crystals of the cubic system. Like the latter, these hollow hexagonal pyramids are the product of the struggle for attraction of material from the surrounding atmosphere; the outer edges, having a wider area to attract material from, grow more than the central portions, which remain uncompleted. We have thus 'skeleton crystals' formed; the centre remains undeveloped, due to the want of material—to 'starvation.' The greater possibilities of attraction are well exemplified by the additional crystal formations at the outer angles of the hexagons, quite similar to the 'hopper' crystals of NaCl.

The crystalline forms are exclusively those of the hexagonal flat-topped prism; never has a terminal pyramid nor a hemihedral shape been observed.

A great variety of forms of skeleton crystals can be observed under favourable conditions; amongst others, helix-shaped hollow pyramids, analogous to the cubic helices of bismuth; also long solid or helix-shaped hexagonal prisms. The hollow pyramids are built of steps of prismatic rings, invariably with a basal pinacoid face.

Often a crystal shows needle-like spikes arranged in decided right angles. This gives the strongest impression of cubic or other rectangular crystals. On careful examination, however, it will always be found that in such a case we have to deal with the incompletely developed rectangular faces of the hexagonal prism, such as we might expect in a skeleton crystal.

A series of micro-photographs and sketches will illustrate this.

The most favourable conditions for the formation of hoar frost crystals and the best opportunities for studying them are found in the refrigerating chambers as used extensively in Liverpool, and through the kindness of the large shipping firm of Messrs. Nelson an excursion and demonstration will be held there.

Department of Physics.

1. *Discussion on the Treatment of Irreversible Processes in Thermodynamics.*[1] *Opened by* J. Swinburne, *M.Inst.C.E.*

The following Papers were read:—

2. *Note on the Rate of Combustion and Explosive Pressure of Cordite.* *By* J. E. Petavel.

The research of which a preliminary account was given is being carried out in the physical laboratories of the Owens College.

[1] Mr. Swinburne's contribution appeared in *Engineering*, August and September 1903.

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The subjects under investigation are:—The effect of the diameter of the cordite, of the charging density, and of the shape of the enclosure.

The curves of rise and fall of pressure are for each explosion automatically recorded, the high-pressure recorder described at a previous meeting [1] being used for this work.

Attention was drawn to the dangerous vibrations which are set up when the charge is not uniformly distributed throughout the enclosure.

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3. *Granular and Spicular Structure in Solids.* *By* G. T. Beilby.

In a communication made to the British Association in 1901 [2] I drew attention to certain facts which had apparently escaped the notice of other observers in micro-metallurgy. It was shown that transparence in metals is not only found in such specially attenuated forms as thin leaves or films deposited on glass, but that it is an intrinsic property of the metal even in its more massive forms. It was further shown that metal surfaces under obliquely reflected light exhibit a remarkably uniform granular or spicular structure which appears to be quite distinct from the crystalline structure revealed by the etching methods of micro-metallurgy.

During the past two years my study of this subject has been continued and extended, and some of the results have been already published.[3]

The object of the present communication is to place on record such confirmation and modification of the original observations and statements as have resulted from the further study of the subject.

The original statements depended on microscopic observations made by obliquely reflected light with objectives of moderate numerical aperture. This form of illumination can only be conveniently applied with objectives whose working distance is not less than 5 mm., and whose front lens is not very large. It was therefore desirable that the observations by obliquely reflected light should be supplemented by others in which different methods of illumination could be employed.

A study was made of films of metal which were thin enough to transmit light freely. By transmitted light, if such films are not too thin, they show a distinct granular texture, as if the substance had been partly gathered up into minute mounds. By alternately illuminating one of these films by transmitted and by obliquely reflected light it is seen that the structure which is granular by one light is spicular by the other; the spicular appearance, therefore, is caused by a granular texture. The slightness of this texture is shown by the fact that it is visible in oblique light in metal films which are less than 10 $\mu\mu$ in thickness.

By a parallel study of the surface-layer in metals in their more massive forms it was found that this layer is in many respects distinct from the mass which it covers, being in its structure and properties similar to the thin films deposited on glass.

The character of the material on which the film is supported has a considerable influence on the appearance by obliquely reflected light. In the case of massive metal the opaque highly reflecting under-surface adds a light and colour to the spicular appearance which is absent in that of the thin glass-supported films. But if due allowance is made for this the correspondence between the appearance of the two, the surface layer and the thin film, is so exact as to leave no doubt as to the identity of the structure which causes this appearance.

The transparence of thin films of metal was studied by Faraday, and some of his conclusions have been confirmed by subsequent observers. His very remarkable observations on the effect of heat annealing on thin films appear to have dropped out of sight. The subject has been studied by me with the help of lenses of a resolving power much greater than any which could be obtained in Faraday's

[1] See *Report, British Association*, Glasgow, 1901, p. 768, and *Phil. Mag.* vol. iii. p. 461, 1902.

[2] Report, 1901, p. 604.

[3] *Proc. Roy. Soc.* vol. lxxii. No. 481.

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time. The results of these recent observations confirm and extend Faraday's conclusions, and it is believed that they also supply an answer to certain questions which he raised.

The condition of the greatest opacity is found in metal films which are in a state of strain, and the condition of greatest transparence is found in films which have been relieved from strain by annealing. Contrary, therefore, to the generally accepted idea, the metal in gold leaf is in its most opaque condition.

Increase of transparence in metals is accompanied by diminution of reflecting power, and *vice versa*. This effect can be seen most distinctly in translucent films, but it is also quite evident in the surface of the more massive forms of metal. Films of gold and of platinum 200 $\mu\mu$ in thickness have been obtained which are translucent and optically continuous. Films less than 10 $\mu\mu$ in thickness have also been made which appear to be equally continuous and are perfectly transparent. The thinner films are practically without metallic reflecting power, while even in the thicker films the reflection is distinctly inferior to that of gold leaf.

The process of annealing has been watched on the surface of metal, and the phenomena were found to be similar in kind to those which occur in films supported on glass or mica. In surface films also the increase of transparence was well marked, and the return of the metal to the more lustrous but less transparent condition of burnishing was evident.

From the study of the phenomena observed in cutting, polishing, burnishing, and annealing I have been led to the conclusion that the disturbance caused by these operations temporarily confers a degree of freedom upon the molecules of the surface layer which enables them to act like a viscous fluid subject to the influence of the molecular forces as they manifest themselves in surface tension. The dimensions and the forms of the grooves, ridges, and granules on the surface give a general indication that the layer affected by this freedom and by the surface tension is many molecules in depth.

It appears probable that the granular structure of the surface is largely a result of surface tension. A similar structure can readily be developed in a very thin film of a viscous fluid. If a little oil is spread on a slip of glass and then almost completely wiped off, so that it is barely visible to the unaided eye, a granular film is produced which gives a well-marked spicular appearance by obliquely reflected light. A film of varnish on a non-reflecting support shows the same structure. A thin film of fuchsin on glass shows a structure and a play of colour which might almost be mistaken for that of a feebly reflecting gold film. Films of oxide or sulphide on metal surfaces show the spicular appearance very brilliantly.

This surface granulation appears to be almost universal, and I have never failed to produce it in any solid with which I have experimented.

Granular or spicular structure seems to be closely associated with the deposition of solids from solution. It is seen in thin films of metal deposited either chemically or electrolytically. In precipitates formed in very dilute solutions there are three stages in the appearance of the solid: (1) spicules or spicular films of extreme thinness, (2) granules, and (3) crystals. Spicules may be formed singly; but they often result from the breaking up of the thin films which are formed at the surface of contact of the two reagents. Their pedetic movements lead to their agglomeration into granules which sink to the bottom of the containing vessel, where they become centres of attraction to the moving spicules and grow by their absorption. Till the granule has reached a certain size and mass it shows no indication of crystalline form or structure, and its form remains, under the control of surface tension, rounded and granular. When a certain size is reached the crystallic force begins to assert itself and to overpower surface tension, and the rounded form begins to develop faces and angles till finally a well-developed crystal is produced.

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MONDAY, SEPTEMBER 14.

DEPARTMENT OF MATHEMATICS.

The following Papers were read:—

1. *On the Differential Invariants of Surfaces and of Spaces.* *By* Professor A. R. FORSYTH, *F.R.S.*

2. *On Spherical Curves.* *By* HAROLD HILTON, *M.A.*

If the stereographic projection of a curve on a sphere from any point is a rational algebraic curve, so is its projection from any other point. One projection is derived from another by an inversion followed by a reflexion in a straight line. In general the projection of such a spherical curve is a plane curve intersecting the line at infinity only in a multiple point at each circule. If the plane curve is of the n-th degree, the spherical curve is said to be of the n-th degree. If it has δ nodes and κ cusps, touches τ great circles in two distinct points, and has ι great circles of curvature, then $m = \frac{1}{2}n^2 - 2\delta - 3\kappa$, $n = m(m-1) - 2\tau - 3\iota$, $\iota = \frac{3}{2}n(n-2) - 6\delta - 8\kappa$, $\kappa = 3m(m-2) - 6\tau - 8\iota$. The deficiency is $\frac{1}{4}(n-2)^2 - \delta - \kappa$. The foci of a spherical curve (*i.e.* the intersections of generating lines which touch the curve) are $(m-n)^2$ in number, $m-n$ being real, and project into the foci of the projection of the curve. Every focus of a spherical curve is a focus of its evolute.

Very many properties of spherical curves may be deduced from known properties of plane curves, and *vice versa*; the simplest cases are the circle and the spherical quartic with zero deficiency. For instance:—'If three small circles are drawn passing through the cusp of a spherical quartic and touching the curve, a circle can be drawn through the focus and their other three points of intersection.'

Some striking theorems can be proved for the real intersections of a real cone and a sphere. If the vertex of the cone lies outside the sphere, we can by two projections reduce the curve to the intersection of a sphere and a cylinder; if the vertex lies inside the cone, we can reduce the curve to the intersection of a sphere and a cone whose vertex is at the centre of the sphere. In either case we can deduce properties of a spherical curve of the $2p$-th degree which lies on a cone by means of known properties of plane curves of the p-th degree. If the vertex of the cone is at the centre of the sphere, properties of the curve may be derived from the fact that the equation of the cone may be put into the shape

$$0 = a_1 a_2 \ldots a_p + a_1(x^2+y^2+z^2)\beta_1\beta_2\ldots\beta_{p-2} + a_2(x^2+y^2+z^2)^2\gamma_1\gamma_2\ldots\gamma_{p-4} + \ldots,$$

where the a's are constants and the a's, β's, γ's are real linear functions of x, y, z. The foci of the intersection of the sphere and the reciprocal cone are the $2p$ poles of the great circles in which the planes $a_1 = a_2 = \ldots = a_p = 0$ intersect the sphere.

Projecting on to the plane we have properties of a curve which is its own inverse with respect to a circle whose centre is real, and whose radius is real or purely imaginary. In particular many interesting properties of bicircular quartics whose four real foci are concyclic may be obtained. For example: 'If P is any point on a bicircular quartic whose four real foci S, S′, H, H′ lie on a circle, and are such that the lines S S′, H H′ meet inside the circle, the circles S P S′, H P H′ make equal angles with the tangent at P.'

To many of the properties of spherical curves correspond properties of curves on a conicoid. To obtain these we project stereographically from the sphere on to a plane, project orthogonally on to another plane, and then project stereographically on to a suitable conicoid. For example: 'If two curves of the fourth degree on an ellipsoid both touch the generating lines through four given real coplanar points, the tangents at a point of intersection of the curves are parallel to conjugate diameters of the indicatrix at that point.'

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3. *The Use of Tangential Coordinates.*[1] *By* R. W. H. T. Hudson.

There are two reasons why it is advisable that a greater use should be made of tangential co-ordinates in elementary analytical geometry. From an educational point of view they are useful in drawing out the student's power of deduction, and exciting his interest in a way in which the long and difficult problems, with which our text-books are crowded, fail to do; and, secondly, there are many theories which find their most natural expression in these coordinates, chiefly because the absolute has a less specialised form in tangential than in point co-ordinates. For example, it is an easy exercise to express the equation of a circle in the form

$$k(l^2 + m^2) + (Gl + Fm + C)^2 = 0;$$

and then, from this, the whole projective theory follows clearly. Again, to take examples from more advanced parts of the subject, the *foci* of the curve

$$\phi(l, m, n) = 0$$

are given by the roots of the equation

$$\phi(1, i, -z) = 0,$$

where $z = x + iy$. The *centre* of a curve of class ν is best defined as the polar point of the line at infinity, and has for equation

$$\partial^{\nu-1}\phi / \partial n^{-1} = 0.$$

From this the property of being the centroid of the points of contact of parallel tangents follows without further analysis.

Great clearness is introduced into the theory of averages in connection with areas and volumes by the exclusive use of tangential coordinates. The equation of the *null-conic* of an area is

$$\iint (lx + my + n)^2 \, dx \, dy = 0,$$

which may, by proper choice of axes and use of the notation of averages, be written in the form

$$l^2 \bar{x}^2 + m^2 \bar{y}^2 + n^2 = 0.$$

Then the *ellipse of gyration* is the confocal

$$l^2 \bar{y}^2 + m^2 \bar{x}^2 - n^2 = 0,$$

and the *ellipse of inertia* is the conic conjugate to the null-conic

$$l^2 \bar{x}^2 + m^2 \bar{y}^2 - n^2 = 0.$$

Finally, the surface of floatation is a good instance. In this case, as in other cases of approximation, it is well to take the standard equation of a plane to be

$$z + n = lx + my$$

so that z and n are small quantities of the second order; and then the plane equation of the surface takes the elegant form—

$$2n + \frac{d}{d\mathrm{V}} \iint (lx + my)^2 \, dx \, dy = 0,$$

the integral extending over the section of floatation and V being the volume immersed.

[1] *Math. Gazette*, No. 42, Dec. 1903.

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4. *The Determination of Successive High Primes.*

By Lieut.-Colonel A. CUNNINGHAM, *R.E.*, *and* H. J. WOODALL.

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5. *Algebraic Curves on Kummer's* 16*-nodal Quartic Surface.*

By R. W. H. T. HUDSON.

The chief difficulty in studying algebraic curves traced on a surface is due to the fact that such a curve is in general not the complete, but only a partial, intersection with another surface, and is, therefore, not representable by only one algebraic point equation in addition to that of the first surface. When the surface can be represented parametrically by means of known functions, a single equation in the two parameters is sufficient to determine the curve, and its properties follow from the known properties of the functions. M. Georges Humbert has proved that *every* algebraic curve on Kummer's surface can be represented by equating to zero a certain kind of theta function.[1] When certain fundamental theorems concerning theta functions have been proved, many important geometrical theorems follow immediately. There are two objections to this procedure. The geometrician who has but a slight acquaintance with transcendental analysis finds the excursion into the realms of hyper-elliptic functions troublesome, and, on the other hand, the arithmetician has doubts as to whether the said fundamental theorems have ever been rigorously proved. The purpose of the present paper is to remove both these objections.

The matrices

$$\begin{pmatrix} a & b & c & d \\ b & -a & d & -c \\ d & c & -b & -a \\ -c & d & a & -b \end{pmatrix} \quad \text{and} \quad \begin{pmatrix} x & z & -y & t \\ y & t & x & -z \\ z & -x & t & y \\ t & -y & -z & -x \end{pmatrix}$$

are obviously orthogonal; they are as familiar as quaternions. The *rows* of the first are transformable into each other by the operators of a group, and, similarly, the *columns* of the second are related to another group of four operators, isomorphic with the former. The product of these matrices is an orthogonal matrix of sixteen linear forms, containing in itself the whole theory of Kummer's configuration of sixteen points and sixteen planes; it is associated with a group of sixteen members, the product of the two preceding groups, which *explains* the existence of the configuration.

The theorem which, it is suggested, may replace Humbert's is as follows: *Every algebraic curve on Kummer's surface is representable by an equation—homogeneous and possessing a certain kind of isobarity in the square-roots of these sixteen linear forms.* If such an equation is squared, the result can be rationalised by the aid of the equation of the surface; whence follows the well-known theorem that along every algebraic curve an algebraic surface can be inscribed; other theorems follow in a like elementary and algebraic manner.

SUB-SECTION ASTRONOMY AND METEOROLOGY.

The following Papers and Report were read:—

1. *Emploie de l'Hygromètre à Cheveu au lieu du Psychromètre.*

By HOFRATH J. M. PERNTER.

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[1] Lionville's *Jour.* ser. 4, vol. ix (1893).

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2. *Was the 'New' Star in Gemini Shining Previously as a very Faint Star?* By Professor H. H. Turner, *D.Sc., F.R.S.*

1. Of about eighteen stars recorded as 'new' in the annals of astronomy, only one (*T Coronæ*) is known to have existed previously as a faint star which suddenly blazed out into prominence. But our records are so incomplete, especially for stars at all faint, that any or all of the eighteen may have been shining as faint stars previous to their blazing up. Since the introduction of photography our records have been more complete, and of several new stars discovered within the last dozen years it is known that they cannot have been so bright as the eleventh magnitude before the outburst: but still they may have been fainter. No photographs happen to have been taken, of the region where they appeared, with sufficiently long exposure to show very faint stars.

2. A 'new' star in the constellation Gemini was discovered at Oxford on March 24 last, and from the splendid photographic records kept at the Harvard College Observatory it was found that the star had been shining brightly since March 6, at least. By great good fortune two photographs of the region where it appeared, showing stars so faint as the fifteenth or sixteenth magnitudes, had been secured just previously, one by Dr. Max Wolf of Heidelberg, on February 16, and another by Mr. Parkhurst, of the Yerkes Observatory, on February 19. Both these show a faint object very close to, if not actually at, the place of the Nova.

3. Copies of these photographs have kindly been sent to Oxford and carefully measured at the University Observatory. The place found for the faint object differs from that found for the Nova by the following quantities:—

	R.A.	Dec.
	″	″
Max Wolf, Feb. 16	−4·8	−2·7
Parkhurst, Feb. 19	−6·3	+1·5

These results leave the question of identity somewhat doubtful. Although the plates agree in indicating a rather large discrepancy in R.A., the images on both plates are of such a character that the differences may be accidental; witness the discrepancy in declination. Dr. Max Wolf's plate is on a small scale, and was magnified five times before measurement; on Mr. Parkhurst's plate the stars are near the edge of the plate. The details will be published in the 'Monthly Notices' of the Royal Astronomical Society.

4. The emphatic suggestion of the result is that we must obtain much more complete records, on a larger scale and showing fainter stars, before we can hope to establish these important questions of identity. Large scale is even more important than in spectroscopic work, for in the latter we get help from the grouping of lines, while with a star all depends on a single coincidence.

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3. *Sur la Circulation générale de l'Atmosphère.* *Par* H. H. Hildebrandsson.

Pour étudier le mécanisme de l'atmosphère, soit dans son ensemble soit dans les régions cycloniques et anticycloniques, il faut d'abord, et indépendamment de toute théorie préconçue, chercher à déterminer avec précision ce qui se passe actuellement dans l'atmosphère, c'est-à-dire constater par des observations directes quels sont les mouvements de l'air non seulement à la surface terrestre, mais aussi dans les régions les plus hautes de l'atmosphère. Déjà en 1872 Clement Ley a commencé à observer pour ce but le mouvement des nuages supérieurs. Il avait fait plus de 600 observations sur les mouvements des cirrus, et en les insérant sur les cartes synoptiques des jours correspondant il a pu démontrer le premier que l'air en haut s'éloigne en général du centre d'une dépression. L'année suivante j'ai réussi à organiser en Suède un réseau de stations pour l'observation des mouvements des nuages, et peu de temps après j'ai réussi à déterminer avec une précision assez grande les mouvements de l'air à différentes hauteurs dans les minima et les maxima barométriques.

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Grâce au concours de mes collègues dans presque tous les pays civilisés du monde, et au travail organisé par le comité météorologique international, des masses d'observation de ce genre sont enregistrées pendant les trente années suivantes, et j'ai essayé à présent à calculer *les mouvements moyens de l'air* à différentes hauteurs au-dessus des différentes parties du globe terrestre. Toutes les représentations des mouvements généraux de l'atmosphère publiées jusqu'ici sont des résultats de considérations théoriques. On a connu assez bien les vents régnant à la surface terrestre, grâce aux travaux d'un Maury, d'un Brault et d'autres, mais sauf quelques observations sur les contre-alizés, faites à quelques points isolés, on a ignoré presque complètement les courants supérieurs de l'atmosphère. Sur ces courants on a dû faire des hypothèses plus ou moins heureuses, en se fondant sur deux principes fondamentaux :

1°. La température de l'air va en décroissant de l'équateur aux pôles ; or il doit constamment exister un vent supérieur ou courant équatorial, soufflant de l'équateur aux pôles, et un vent inférieur ou courant polaire, soufflant des pôles à l'équateur.

2°. Quelle que soit la direction suivie par un courant atmosphérique, la rotation terrestre dévie ce courant à droite dans l'hémisphère boréal, à gauche dans l'hémisphère austral.

Le premier principe fut énoncé par Halley en 1686 et l'autre par Hadley en 1735.

La théorie sur la circulation générale de l'atmosphère adoptée jusqu'ici fut exposée par feu James Thomson à la séance de l'Association Britannique en 1857. Il admet au-dessus de chaque hémisphère deux courants principaux superposés. L'air qui monte en haut au-dessus des environs de l'équateur marche comme courant supérieur jusqu'aux environs du cercle polaire et retourne comme courant polaire inférieur vers l'équateur. Cependant les observations ayant montré qu'il règne en général à la surface terrestre dans les zones tempérées des vents du S.W., il admet que ces courants n'appartiennent qu'à une couche mince formant une espèce de courant de réaction entre le courant boréal et la surface terrestre. Tous les trois courants ainsi superposés auraient une déviation vers l'est et serait S.W., N.W. et S.W. Evidemment on pourrait croire que le courant polaire serait un vent du N.E., selon la théorie de Hadley ; mais Thomson admet qu'il est dévié vers l'est, '*in virtue of a revolutional momentum brought from equatorial regions, and not yet exhausted.*'

Ferrel a, comme on sait, construit théoriquement trois circulations générales de l'atmosphère, dont la dernière de 1889 ne diffère de celle de James Thomson que par quelques détails peu importants.

Cette théorie a été en général adoptée jusqu'à présent. Mais on peut bien se demander, comment est-il possible que trois courants réguliers puissent se former de cette manière dans une couche dont l'épaisseur en comparaison avec l'étendue horizontale est si petite qu'on peut bien le comparer avec une feuille de papier ? Pour trouver directement sans aucune théorie conçue d'avance quels sont les mouvements vrais des courants atmosphériques nous avons calculé toutes les observations des mouvements des nuages recueillies depuis trente années. Voici les résultats.

Zone Tropicale.—Les observations de la zone tropicale font toutes voir que les courants atmosphériques y sont à toute hauteur et presque sans exception dirigés de l'est à l'ouest.

Zone des Alizés.—On a admis que le contre-alizé est dirigé partout du S.W. au nord, et du N.W. au sud de l'équateur, et on a prétendu, comme nous venons de le voir, qu'il est prolongé dans les régions supérieurs jusqu'à vers le cercle polaire. Des excellentes observations faites à Maurice, très bien situé au milieu de la zone de l'alizé du S.E. dans la Mer Indienne, on voit en effet par plus de 3,000 observations des cirrus pendant plus de vingt années que le contre-alizé y est constamment du N.W. Il est donc probable que ce vent supérieur souffle du S.W. au-dessus du milieu de la zone des alizés de l'hémisphère boréal. Mais l'idée que ce courant continuerait comme courant supérieur du S.W. jusqu'au

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cercle polaire est erronée. En effet, le contre-alizé est, comme tous les vents de l'hémisphère boréal, dévié à droite, et *aux limites polaires des alizés il est devenu déjà un vent d'ouest.* La marche des cirrus en hiver est de W. 15° S. au-dessus de Ténériffe, et presque toujours de l'ouest à San Fernando, situé à peu près à la crête du maximum barométrique du tropique de Cancer. La direction des cirrus est aussi à peu près de l'ouest à Lisbonne, et les observations toutes récentes des Açores semblent donner le même résultat.

Les alizés et les hautes pressions aux tropiques, par lesquelles ils sont causés, ont, comme on sait, une oscillation annuelle, se déplaçant toujours avec le soleil du nord au sud et *vice versa.* Ainsi une large bande au nord de l'équateur thermique est couverte en hiver par l'alizé de N.E. et en été par la zone des calmes aux vents de l'est tropicaux. En haut il règne ici tantôt le contre-alizé de S.W., tantôt le courant tropical de l'est. *C'est la région des moussons supérieures.* Cela est démontré par les observations du square 39 sur l'Océan Atlantique, de Mexique, de la Havane (Cuba), de Manille (Philippines), etc.

Zones Tempérées.—Le rév. P. Marc Decheverens a démontré le premier en 1885 que la direction moyenne des nuages supérieurs est constamment de l'ouest dans les parages de Shanghai, en Chine, et la même année nous avons trouvé la même chose pour l'Europe.

Depuis ce temps nous disposons d'une quantité très grande d'observations des différentes parties de la zone tempérée de l'hémisphère boréal. Partout, en Amérique, en Europe, en Sibérie, en Chine et en Japon, *il règne partout en moyenne un courant supérieur de l'ouest à l'est pendant tous les mois de l'année.* Pour plusieurs stations nous avons des observations et des vents et des directions des différentes espèces de nuages flottant à des hauteurs différentes. Alors on voit avec surprise que les grands courants des moussons asiatiques sont des courants très minces qui n'existent plus à une hauteur de 4,000–5,000 m. Au-dessus d'eux le grand *tourbillon polaire* de l'ouest à l'est existe toujours.

En étudiant de plus près ce qui se passe dans le sein de ce vaste tourbillon qui embrasse toute la zone tempérée nous avons trouvé que l'air y se meut de la même manière que dans un tourbillon ou un cyclone ordinaire: l'air des couches inférieures s'approche du centre et celui des couches supérieures s'en éloigne de plus en plus avec la hauteur au-dessus de la surface terrestre. Pour les régions plus hautes que la couche où flottent les cirrus nous n'avons plus de nuage. Cependant nous avons des observations des ballons sondes qui ont dépassé de beaucoup la région des cirrus et atteint souvent des hauteurs de 15 à 18 kilomètres, communiquées à nous par M. Teisserenc de Bort. Il résulte qu'en haut, jusqu'aux hauteurs les plus grandes qu'on ait pu atteindre jusqu'ici, l'air est doué d'un mouvement de l'ouest à l'est avec une composante de nord croissant avec la hauteur.

Par conséquent les courants supérieurs du sud indiqués dans les systèmes de J. Thomson et de Ferrel *n'existent pas* au-dessous de 15 à 18 kilomètres, et la *masse* de l'air qui se trouve plus haut est vraiment très petite. *Il faut donc abandonner une fois pour toutes cette idée d'une circulation verticale entre les tropiques et les pôles*—circulation qui, comme nous l'avons dit plus haut, semble impossible pratiquement dans une couche dont l'épaisseur est très petite en comparaison avec les distances horizontales. Espérons que dès à présent ces 'courants polaires' et 'équatoriaux,' qui ont fait tant de confusion dans la météorologie dynamique, disparaîtront enfin complètement de la science météorologique, au moins dans le sens dans lequel on les a adoptés jusqu'ici.

Mais si dans le tourbillon polaire l'air dans les couches supérieures s'éloigne du centre nous devons attendre que les courants supérieurs, sortant de ce tourbillon, envahissent la pente boréale de la haute pression du tropique, qui serait ainsi alimentée des deux côtés: par le contre-alizé du côté sud et *par un courant de N.W. du côté nord.*

C'est précisément ce qui a lieu. A la latitude de 40° environ, à Washington, à Madrid, à Perpignan, à Pola, à Tiflis et au-dessus du Golfe de Perse, partout la direction moyenne des cirrus est du N.W.

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Résumé.

Nous avons prouvé *par des observations directes* les résultats suivants :

1°. Au-dessus de l'équateur thermique et les 'calmes équatoriaux' il existe pendant toute l'année un courant *de l'est*.

2°. Au-dessus des alizés il règne un contre-alizé du S.W. sur l'hémisphère boréal et du N.W. sur l'hémisphère austral.

3°. Ce contre-alizé ne dépasse pas la limite polaire de l'alizé : il est dévié de plus en plus à droite sur l'hémisphère nord et à gauche sur l'hémisphère sud pour devenir un courant de l'ouest au-dessus de la crête du maximum barométrique des tropiques, où il descend pour alimenter l'alizé.

4°. Les régions situés au bord équatorial de l'alizé entrent avec les saisons tantôt dans l'alizé, tantôt dans les calmes équatoriaux. Au-dessus d'elles il y a par conséquent une mousson supérieure : le contre-alizé en hiver et le courant équatorial de l'est en été.

5°. Des hautes pressions des tropiques la pression de l'air diminue en moyenne continuellement vers les pôles, au moins au delà des cercles polaires. Aussi l'air des zones tempérées est-il entraîné dans un vaste *tourbillon polaire*, tournant *de l'ouest à l'est*. Ce mouvement tournant semble être de la même nature que celle d'un cyclone ordinaire : l'air des couches inférieures s'approche du centre et celui des couches supérieurs s'en éloigne de plus en plus avec la hauteur au-dessus de la surface terrestre jusqu'aux régions les plus hautes dont nous avons des renseignements.

6°. Les nappes d'air supérieures des zones tempérées s'étendent au-dessus des hautes pressions des tropiques pour y descendre.

7°. Les irrégularités qu'on trouve à la surface terrestre, surtout dans les régions des mousons en Asie, disparaissent en général déjà à la hauteur des nuages inférieures ou intermédiaires.

8°. Il faut abandonner complètement cette idée d'une circulation verticale entre les tropiques et les pôles de la manière admise jusqu'à présent selon J. Thomson et Ferrel.

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4. *Report on the Investigation of the Upper Atmosphere by Means of Kites.*—See Reports, p. 31.

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5. *Results of the Exploration of the Air with Kites at Blue Hill Observatory, Mass., U.S.A., during* 1900–2, *and the Use of this Method on the Tropical Oceans. By* A. Lawrence Rotch, *B.S., M.A., Director of the Observatory.*

The progress of the work at Blue Hill, since its inception there in 1894 until 1901, has been presented annually to this Section of the British Association. The observations in forty-five flights during 1900–2 have been plotted on the sheets shown, a study of which forms the chief portion of this paper. Marked inversions of temperature, accompanied by corresponding changes in humidity and wind-velocity, are found to occur at all heights, instead of only at the greater heights observed by aëronauts. An investigation of the decrease of temperature obtained in twenty kite-flights at Blue Hill, up to an extreme height of 13,000 feet, indicates that, while the mean decrease of temperature, computed by stages of 1,600 feet, is slightly greater in areas of low barometric pressure than in areas of high pressure, yet the rate of decrease of the temperature tends to become less with increasing altitude. On the contrary, in areas of high barometric pressure there appears to be no diminution in the rate, indicating that at heights greater than 13,000 feet the temperature of the whole column of air may be colder when the pressure at the ground is high, than when it is low. During 1901 records were obtained from the kite-meteorograph in ten flights, the average of the highest points obtained in

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each of these flights being 7,870 feet above sea-level, and the greatest height being 12,550 feet. Beginning with December 1901, kite-flights, in co-operation with similar ascents of kites and balloons in Europe, were attempted every month upon a certain day that was appointed by the International Committee for Scientific Aëronautics, of which the writer is the American member. During 1902 thirteen flights were made, of which ten were upon the international days specified.

In two of the flights the upper kites broke away and were lost in the ocean, but it is probable that the height obtained during one of them exceeded 16,000 feet. The average height of the flights from which records were obtained is 7,940 feet, being little more than during the preceding year, but the maximum height of 14,060 feet is considerably greater. The reason that flights were not made on all the international days was lack of wind at the ground, and sometimes it was impossible to get higher than the cumulus clouds on account of the wind failing at that level. Occasionally the strength of the wind at high altitudes was an obstacle to further progress upward, and caused the accidents already mentioned. Were it desired to fly kites every day, or with certainty on any pre-determined day, duplicate kites and apparatus might be installed on board a small steamboat, which by steaming in Massachusetts Bay could create an artificial wind to raise the kites or reduce the wind to a suitable velocity.

The possibility of thus becoming independent of the natural wind by flying meteorological kites from a vessel appears to have been first shown by the writer in 1901, when he described his experiments to Section E of this Association at Glasgow. The subsequent successful use of this new method of meteorological research by European colleagues is related in 'Science,' vol. xviii. pp. 113, 114. The most important application of this method would be to the investigation of the meteorological conditions above the trade-winds and doldrums, a project which the author presented to the International Aëronautical Congress at Berlin in 1902. The accepted theories as to the motion of the upper currents, or anti-trades, are not sustained by the observations of the movements of volcanic dust and high clouds.

Moreover, we are ignorant concerning the depth of the trades, and know nothing about the vertical variations of temperature and humidity over the ocean, nor whether sudden changes in these elements occur between the trades and the anti-trades. The author desires to make atmospheric soundings with kites flown from a vessel between the Azores and Ascension Island, and is endeavouring to obtain the funds to charter and equip a steamer, believing that in this way some of the most important problems in meteorology and physical geography may be solved.

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6. *Work of the International Aëronautical Committee.* *By* Professor H. Hergesell.

Professor Hergesell, als Präsident der internationalen Kommission für Luftschiffahrt, giebt einen Bericht über die aeronautische Arbeit, die bisher von dieser Kommission gemacht ist. Die Kommission, 1896 gelegentlich der Konferenz der Directoren des Meteorologischen Instituts in Paris ins Leben gerufen, hat die Aufgabe durch gemeinsame internationale Arbeit die hohen Schichten der Atmosphäre zu erforschen. Eine ihrer Hauptaufgaben ist die Ausführung simultaner Aufstiege von möglichst vielen Punkten der Erdoberfläche. Um dieses Werk durchführen waren viele Schwierigkeiten zu überwinden. Zunächst galt es für diese Auffahrten ein möglichst einwandfreies Instrumentarium zu schaffen. Ziemlich gelangte man am besten durch gemeinsame Besprechungen, die auf drei Konferenzen der Kommission, 1898 zu Strassburg, 1900 zu Berlin und 1902 zu Berlin, abgehalten wurden. Die Sitzungsberichte finden sich in den offiziellen Berichten, die von dem Präsidenten der Kommission veröffentlicht worden sind.

Professor H. Hergesell concluded his remarks as follows:—

In making prominent at this place the development of our studies, I do so in the hope that English meteorologists also will take part in our experiments. I

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have already mentioned the occasional ascents conducted by Mr. Alexander with unmanned balloons, but I hope that we shall likewise have the permanent assistance of the great British Empire. The foundation of an aëronautical observatory and a kite station on these shores is of the greatest importance for our studies. With the help of ship-motion it would be possible to send up self-recording instruments every day. I have seen, not without emotion, here in the exhibition, those classical instruments which were used many years ago by your celebrated James Glaisher, whom we are proud to have had on the list of our honorary members. They are to me a sure sign that English science, remembering his great services, will take a prominent place in our aëronautical investigation of the upper atmosphere.

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7. *Photographs of the Orion Nebula.* *By* W. E. Wilson, *F.R.S.*

It is not possible to produce from a long exposure negative of the Orion nebula a direct positive which will show at once both the detail in the bright central portions and the faint extensions. The author has succeeded, by means of screening off gradually the outlying portions, in obtaining the desired result, and suggests that the method is in some ways preferable to the method of local reduction of the original negative.

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8. *Lightning and its Spectra.*
By W. J. S. Lockyer, *M.A.*, *PhD.*, *F.R.A.S.*

This paper consists of a brief reference to the different types of lightning flashes, such as multiple, band, &c., and an account of the method adopted by the author in securing their spectra. He showed that by the use of small hand or stand cameras, with the addition of a Thorpe transparent grating placed before the objective, not only could the spectra of bright flashes be secured, but an image of the flash in each case obtained. Two flashes with their spectra were shown, the latter showing in one case not only bright but apparently dark lines. These photographs, together with others, were obtained by the author on the morning (3 A.M.) of May 31, 1903, using in one case a 5 × 4 Cartridge Kodak, and in the other a 8½ × 6½ Dallmeyer rapid rectilinear attached to a box camera. Both spectra, which resembled each other to a great extent, differed from those secured by Professor E. C. Pickering. He then illustrated different photographs of the spectra of sparks in air taken with the same instrument, showing the changes in the spectra as the air was varied by the addition of small quantities of nitrogen or oxygen, or by allowing a great number of discharges to occur before analysing the spectrum. A comparison of these spectra was then made with those of the actual lightning flashes. The author expressed no definite results of this comparison, as the investigation was not yet completed.

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9. *On the Phenomena accompanying the Volcanic Eruptions in the West Indies.* *By* David Burns, *C.E.*

Armstrong's hydro-electric machine was in its day unrivalled as a source of high electric power. Faraday ascribed the electricity to the friction of the particles of water in the issuing steam against the sides of the jet. The author supposes that electricity was likewise created in immense quantity by the friction of steam and ash against the sides of the vent of the volcano during the eruptions, and that Mont Pelée and La Soufrière have in their composition beds of low conductivity, so that the mountain becomes intensely electrified, and also the clouds of steam and ash over them. The two theories that have been put forward of the 'blast' are discussed; the explosive cloud theory is considered untenable, and calculations are given to show that the gravitation theory of the British Scientific Expedition is inadequate. The 'blast' is ascribed by the author to the repulsion

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between the electrified mountain and the similarly electrified incandescent sand; and also to the attraction of the mountain for the oppositely electrified cloud above. The principal cause of death is ascribed to electric shock, and the overthrow of the cannon and image on the battery hill of St. Pierre is cited as an instance of destruction that could only have been brought about by electric means.

TUESDAY, SEPTEMBER 15.

DEPARTMENT OF MATHEMATICS AND PHYSICS.

The following Report and Papers were read:—

1. *Report of the Committee on Electrical Standards.*—See Reports, p. 33.

2. *Note on Carbon and Iron Arc Spectra at High Gaseous Pressures.* *By* R. S. HUTTON *and* J. E. PETAVEL.

The paper gives an account of a preliminary investigation of arc spectra at pressures up to 100 atmospheres.

Two points are worthy of note. Firstly, a sharp reversal of the cyanogen band 3883 in the carbon arc spectrum. Secondly, the reversal of a large number of lines in the ultra-violet part of the iron spectrum.

Incidentally it was found that the discharge of a high-tension alternating current of large intensity between iron electrodes fills the whole of the partially evacuated enclosure with a brilliant yellow glow. A study of this glow has shown a considerable simplification of the iron spectrum.

3. *How to Exhibit in Optical Instruments the Resolution of Light into its Component Undulations of Flat Wavelets, and how to Employ this Resolution as our Guide in Making and in Interpreting Experiments.* *By* G. JOHNSTONE STONEY, *M.A., Hon.Sc.D., F.R.S.*

The present communication is the third of a series of papers on a new method of dealing with optical problems, based on the fact that, however complex the light traversing a given space may be, it always admits of being resolved into components, each of which is an undulation of uniform flat wavelets sweeping across that space. The chief peculiarity of this resolution is that the components undergo no change as they advance. This gives the resolution into flat wavelets an advantage over every other method of resolving light.

The first paper, published in the 'British Association Report' for 1901, p. 570, gives a more direct and more easily understood proof of the fundamental theorem than that which had some years previously been given by the author. The second paper, of which an abstract is given in last year's 'British Association Report,' and which appears in full in the 'Philosophical Magazine' for February 1903, explains how to construct a reference hemisphere and indicator diagram, which makes it easy to employ the new method of resolution in the chamber study of optical problems; and in the present paper an explanation is given of how to exhibit the contents of this indicator diagram when making experiments with optical instruments. Thus, in the case of the microscope, the light from the objects upon the stage has to pass through a stratum of either air, water, or oil before entering the objective; and if we conceive the light traversing this stratum to be resolved into its component undulations of flat wavelets, then portions of these—that is to say, beams which we may imagine to be cut out of them—enter the objective and are brought to a focus by it, in an image which may be seen by removing the eyepiece and looking down the tube of the instrument.

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Each optical punctum of this image is the concentrated light of one or of a small group of these beams; and it can be proved geometrically that the image so formed is a part of the indicator diagram, and possesses the valuable properties of that diagram which were explained in the paper read last year. In virtue of these properties we can, by scrutinising the image seen on looking down the tube, ascertain by observation the directions, intensities, and colours of the component undulations of flat wavelets into which the light, as it travels from the object under examination to the objective, necessarily resolves itself. This prepares the way for making and interpreting a great body of valuable experiments.

The full paper will appear in the 'Philosophical Magazine.'

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4. *On the Form of Lagrange's Equations for Non-Holonomic Systems.*[1]

By Professor LUDWIG BOLTZMANN.

If a system is given of n material points, with the rectangular co-ordinates $x_1 x_2 \ldots x_{3n}$ and if between the co-ordinates we have ν equations, the system can be characterised by $3n-\nu$ generalised co-ordinates. If some of the ν equations have the form $\xi_1 dx_1 + \ldots \xi_{3n} dx_{3n} = 0$, and if τ cannot be reduced to the form $d\phi(x_1 x_2 \ldots x_{3n}) = 0$, then we call the system non-holonomic of the order τ. Then also at least τ equations between the rectangular and generalised co-ordinates must have the form $dx_k = \eta_{1k} dp_1 + \ldots \eta_{3n-\nu} dp_{3n-\nu}$, and Lagrange's equations are no longer true. Professor Boltzmann develops the members which must be added to Lagrange's equations in this case, and gives a very simple and striking example. The complete paper will be found in the 'Sitzber. d. Akademie in Wien,' Bd. 111, p. 1603, December 18, 1902.

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5. *Wave-propagation in a Dispersive Medium.*

By Professor A. SCHUSTER, *F.R.S.*

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6. *Discussion on the Use of Vectorial Methods in Physics.*[2]

Opened by Professor O. HENRICI, *F.R.S.*

Contribution by JAMES SWINBURNE, *M.Inst.CI.*

Such a question as this does not concern only the writers of mathematical books; it is essentially important to physicists. My own unfortunate experience is probably that of very many others. Coming on the notion of quaternions, or at any rate of vectors, in Maxwell, one had recourse to Tait. As this was nearly twenty years ago, Hamilton was not accessible, except in Glan's German translation. After working at an idea that promised great simplicity in the future treatment of electrics, with the notion that it would come into use, I found my trouble wasted, for Heaviside's system came along. Then there came all sorts of minor modifications. I have now forgotten all about both systems, and have no intention of troubling my head with any of them in future. Until mathematicians settle among themselves what system is to be adopted, and bury all the others, the ordinary man will not take up any of them. Working with collections of direction cosines and differential equations which have a perspective is very tedious. To follow the meaning of them is great mental labour, and it involves a peculiar sort of imagination, akin to that necessary for playing chess in a far-seeing way, or blindfold—a sort of mental imaging. Whether the Cambridge mathematician pictures these things in his mind, or degenerates into a user of blind mathematics,

[1] Printed *in extenso* in the *Sitzber. Ak. der Wiss. in Wien*, Bd. cxi.

[2] Professor Henrici's opening remarks are printed *in extenso* in the Reports, p. 51.

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might be left to his own conscience, if he had one. I doubt if ever a Cambridge mathematician could work either quaternions or vector products blindly. This, in addition to its simplicity, is a great advantage in either sort of vector method.

But mathematical writers forget that readers are not specialists in their particular branches; and if an author has a new notation, or unfamiliar conventions, the reader simply cannot bother with it. People do not read books; they dip in and abstract the particular bits of information they want, and if they come across new conventions, or notation, they cannot read the whole book to find out what is meant. Mathematical writers, among their other numerous faults, generally omit to index, and bury definitions in the letterpress, so that they cannot be found except by reading the book from the beginning. They also forget that their readers do not spend their whole time at mathematics, and do not keep the subject in a state of bright polish. An ordinary man, who may be reading physics one hour, and specifying for sewage pumps or interviewing a town council the next, cannot keep his head clear about the idiosyncrasies of different writers; they are inessential, and are a nuisance.

If Professor Henrici can induce a committee of influential mathematicians, and especially physicists, to discuss the matter and settle what system to adopt, and stick to it, we may get rid of x, y, and z, and gain simplicity; but as long as there is continual tinkering there is no chance of the adoption of any system. It would be better to adopt the worst system than go on as at present. It is for specialists, not for people like me, to say what is wanted. I may put in a plea as a possible though ignorant user. I have no religious objection to the square of a vector being negative. Being an engineer, an ordinary screw is right-handed or positive; and for mathematicians there is the corkscrew. I want a system that fits in with the electric and magnetic circuits, and I want it to make geometrical sense of $\sqrt{-1}$, Demoivre's theorem, and the exponential values of the trigonometric functions and the hyperbolic functions. We do not want several sets of conventions to cover all these points. I do not speak personally, merely as an outsider representing, probably, many hundreds of physicists. We all want some system—one system, and only one system.

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7. *Consideration of some Points in the Design and Working of Ballistic Galvanometers.* By P. H. Powell, *B.Sc.*

The D'Arsonval type of galvanometer is at the same time one of the most accurate and one of the simplest of galvanometers, and is exceptionally suitable for use in the neighbourhood of powerful electromagnets.

A ballistic galvanometer is usually designed to have a certain periodic time and a certain sensibility; it should be quick-working—*i.e.* should be able to be brought to rest quickly at zero after the deflection has been read.

The deflection of the galvanometer is a measure of the quantity of electricity discharged through the instrument. It is assumed that the discharge takes place before the suspended coil of the instrument has appreciably moved; consequently the periodic time must depend upon the time during which the discharge passes, and can be fixed accordingly. Hence the two data, sensibility and periodic time, can be easily chosen, the remaining condition being left for further consideration.

Consider a coil whose length is a, breadth b, mass M, wound with n turns of wire, and suspended between the poles of a permanent magnet which creates a uniform field of intensity H.

Then, after the impulse has been given,

$$Mk^2\ddot{\theta} = -C\theta,$$

neglecting damping (where C is the control), and hence

$$\text{Time of free oscillation } T = 2\pi\sqrt{\frac{Mk^2}{C}} \quad . \quad . \quad . \quad . \quad (1)$$

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From initial conditions—

$$\dot{\theta}_0 = \frac{Hnab}{Mk^2}Q,$$

and hence the deflection

$$\theta_{max.} = \frac{HnabQ}{\sqrt{MCk^2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From equations (1) and (2) it is possible to design an ordinary galvanometer; the only other consideration is the damping.

Now the retarding couple on the coil due to damping

$$= (Hnab)^2 \frac{\dot{\theta}}{R} \qquad \text{(R in C.G.S.)}$$

Introducing this term into the equation of motion,

$$Mk^2\ddot{\theta} + \frac{(Hnab)^2}{R}\dot{\theta} + C\theta = 0,$$

and critical damping takes place when

$$R = \frac{(Hnab)^2}{2\sqrt{MCk^2}} \quad \text{C.G.S. units} \quad . \quad . \quad . \quad . \quad (3)$$

In order that the motion of the coil may be effectively stopped by short-circuiting, its resistance must not be greater than the value given by this equation. When a deflection is being read, however, in order to render the damping term inappreciable the total resistance of the circuit must be considerably greater than this value. This can be readily arranged by suitable connections.

From these equations it is seen that the only method by which it is possible to decrease the period and still keep the sensibility constant is by decreasing the control C. If the period is brought down by other means there will be a loss of sensibility.

In a special case a galvanometer was required to have a very low period with a fairly high sensibility and quick working, and this investigation was undertaken in order to obtain a satisfactory instrument.

From calculations founded on the above equations a design was made, assuming a certain size of coil and shape of magnet, which was sent to a certain firm of instrument-makers, so that they could inform us of the value of the strength of the magnetic field in the gap. This was found to be 230 lines per square centimetre, and from experiments on the torsion of phosphor bronze strip it was found that a control of ·01 would not be difficult to obtain.

Assuming a coil, length 5 cm., breadth 1·72 cm., a control of ·01 (dyne cm.), a periodic time of 80 secs., and a sensibility of $\frac{1}{4}$ radiam per microcoulomb (*i.e.* $\frac{1}{8}$ radiam as motion of coil), then the coil must contain 22 turns of No. 28 wire.

On testing for damping the critical resistance is found to be 7·1 ohms, which, being much larger than the resistance of the coil, indicates that the motion of the coil could be easily stopped by short-circuiting.

From these results the galvanometer was constructed, and was found to have a much higher period and much lower sensibility than it had been designed for. The cause of this was not far to seek, lying in the fact that the copper wire used in the construction of the coil was magnetic, and it was found that this magnetic control was very large in comparison with the feeble control of the strip.

To overcome this difficulty various devices were tried, and wire was obtained from several manufacturers, in the hope that it would prove non-magnetic. The best results were obtained, however, by depositing copper electrolytically on a very fine wire. The resulting copper wire was fairly non-magnetic, but so brittle that it could not be used. To improve the wire it was rolled between brass rollers and annealed; but in doing so some very fine iron dust floating in the air of the workshop must have become deposited on it, for it was again found to

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be magnetic. The attempt to produce pure copper wire was then abandoned, and in order to reduce the magnetic control a very narrow coil was procured, and by putting pole pieces on the permanent magnet its field was made as uniform as possible, since in a perfectly uniform field magnetic particles on the coil would not produce any control. In order to increase the moment of inertia of the system a light copper disc was attached rigidly to the coil by a light bone rod.

This arrangement when tried gave satisfactory results as regards sensibility and periodic time, but did not damp well when short-circuited. This difficulty was overcome by placing below the copper disc a small electromagnet, which when excited quickly brought to rest the disc by reason of the eddy currents induced in it.

There is one point of interest about the method adopted in calibrating the new instrument. This is done best by the standard solenoid, as the deflections are not proportional to the quantity of electricity discharged through the coil when the resistance in the circuit is small. Taking a series of readings, curves can be plotted showing the relation between flux-deflection for constant resistance and resistance-deflection for constant flux; or the three may be plotted isometrically. This last is the most convenient method for odd deflections, but when several readings are taken with the same resistance it is better to plot a separate curve connecting flux and deflection for each resistance from the set of curves connecting deflection and resistance for constant flux.

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8. *On the Use of Capacities as Multipliers for Electrostatic Voltmeters in Alternating Current Circuits.* *By* Professor E. W. MARCHANT, *D.Sc.*, *and* G. W. WORRALL, *B.Sc.*

This arrangement has been devised to enable an electrostatic voltmeter to be used to measure any alternating voltage higher than that actually existing between its terminals.

Two capacities having a known ratio are placed in series with each other across the circuit the P.D. of which it is desired to measure, and the voltmeter is shunted across one of them. If the resistance of the circuit be very high there will be an alternating current flowing through the condensers, whose R.M.S. value for a uniwave is given by

$$I = \frac{EC_1 C_2 p}{C_1 + C_2} \text{ ampères.}$$

where C_1 and C_2 are the magnitudes of the capacities in farads.

E is the R.M.S. value of the applied P.D. in volts.

And $p = 2\pi \times$ frequency.

The P.D. between the terminals of C_2 will be $= \frac{I}{C_2 p} = \frac{EC_1}{C_1 + C_2} = V.$

Hence
$$\frac{V}{E} = \frac{C_1}{C_1 + C_2}.$$

By adjusting the capacities C_1 and C_2 it is thus possible to obtain any desired ratio between the voltage at the terminals of the instrument and that on the circuit.

This relationship has been worked out for a uniwave, which, of course, rarely exists; but it may easily be shown that the same ratio between the voltages on the circuit and the voltmeter holds for all wave-shapes.

There are two conditions which have to be fulfilled to ensure accuracy:

(1) The insulation resistance of the condenser must be so high as to make the resistance current very small compared with the capacity current.

(2) The shunting capacity must be large compared with that of the instrument itself.

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This device cannot be used successfully with direct currents, since though, theoretically, the voltage distribution would be the same as for alternating potential differences, the defective insulation of all condensers (unless constructed with excessive care) allows the charge to leak away, and the actual reading of the voltmeter depends on the ratio of the resistances of the two branches of the circuit.

Very high insulation of the condensers is not desirable when they are used with alternating currents, as an accidental electrostatic charge would be retained and vitiate the readings.

The two capacities may be combined to form one piece of apparatus. The condenser is arranged with one set of conducting plates all connected together, the other set being split into two groups, one of which forms, with the corresponding plates of the first set, one condenser, and the second group, with the remaining plates of the first set, the second condenser. For high voltages the whole may be immersed in oil.

Experiments have been made with this device, using various ratios, including one of 20:1, in which a P.D. of 10,000 volts was measured with an ordinary 500-volt electrostatic instrument.

This method has been previously described by W. Penkert in 'Elecktrotech. Zeits.' No. 39 (1898), 'Eclairage Electrique,' 17, p. 332 (1898), and 'Science Abstracts,' 1899, p. 294.

SUB-SECTION OF ASTRONOMY AND METEOROLOGY.

The following Report and Papers were read:—

1. *Report of the Seismological Committee.*—See Reports, p. 77.

2. *Exhibition of Photographs made with the Spectro-Heliograph of the Yerkes Observatory.* *By* A. R. HINKS, *M.A.*

3. *Radiation through a Foggy Atmosphere.*
By ARTHUR SCHUSTER, *F.R.S.*

In the theoretical explanation of the appearance of dark lines in the spectra of the sun and the stars a mass of gas is supposed to act on the incident light by absorption only. When Kirchhoff first furnished this explanation it fitted all the facts which were then known, and it was not necessary to go beyond the assumption of simple absorption. But difficulties have since arisen. Bright lines are observed to be mixed with the dark lines in some stellar spectra, and even in the sun the H and K lines are bright over a great portion of the disc.

According to Kirchhoff's hypothesis a layer of gas in front of a radiating surface can only give bright lines if its temperature is higher than that of the radiating surface; a supposition which in the case of stellar or solar atmospheres is not perhaps impossible, but certainly to be avoided if possible.

The presence of bright lines admits, however, of easy explanation if we take the scattering of light into consideration, which must, to some extent, take place in a pure gas, and must certainly prevail under the conditions of the condensable vapour in front of stellar photospheres. The scattering of light acts in a different manner from absorption, and should therefore be taken into account. I call a vapour in which scattering plays an appreciable part a 'foggy' vapour.

The coefficient of scattering (s) is conveniently defined thus: If streams of radiation of intensity A fall on a plate of infinitely small thickness h, an amount of light is scattered by the plate which, per unit surface, may be expressed by sAh. Of this $\frac{1}{2}$ sAh is sent backwards and $\frac{1}{2}$ sAh forward. The amount of radia-

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tion absorbed is similarly $\kappa A\lambda$, where κ is the coefficient of absorption which is equal to the coefficient of emission. I shall also write

$$\gamma = \left(\sqrt{1 + \frac{\kappa}{s}} + \sqrt{\frac{\kappa}{s}}\right)^2$$

We may then express some of the results obtained as follows, the complete investigation being reserved for publication in the 'Astrophysical Journal.'

1. A plate of infinite thickness sends out an amount of radiation

$$\frac{\gamma - 1}{\gamma} R$$

where R is the radiation of a black body having the temperature of the plate. Thus if $\kappa/s = \frac{1}{2}$, 1, or 2, $(\gamma - 1)/\gamma = \cdot 73$, $\cdot 83$, or $\cdot 92$ respectively.

A great thickness of a foggy vapour therefore does not tend to give a continuous spectrum, but one of bright lines. The brightest line will be that which has the greatest emissive power.

2. An absorbing and radiating layer of a foggy vapour placed in front of a luminous surface of higher temperature may show bright lines as well as dark lines.

3. The continuous spectrum transmitted through such a layer, if there is no absorption, has an intensity

$$\frac{2}{2 + st} A$$

where t is the thickness of the layer, and A the intensity of the incident light. A line will be dark or bright according as the intensity belonging to its radiation value smaller or greater than this.

4. The radiation of the background and the coefficient of scattering being equal, the brightest lines belong to the radiations of greatest emissive power. This explains the absence of the helium line D_3 from the spectrum of the sun.

5. Under the conditions probably holding in the stars, where in consequence of lower temperature the ratio of black radiation of the absorbing layer to that of the photosphere is decidedly greater for the red than for the violet radiations, the less refrangible rays are more easily reversed than the more refrangible rays. This probably accounts for the fact that stars are apt to show the less refrangible hydrogen lines bright, and the more refrangible hydrogen lines dark.

6. If the scattering is due to small particles, so that the short wave-lengths are much more scattered than the longer waves, the above result may be reversed, and the *most* refrangible lines may be those most easily seen as bright lines. This is apparently the condition which holds on the sun, as the ultra-violet hydrogen lines do not show as absorption lines in the solar spectrum.

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4. *Eclipse Observations of Jupiter's Satellites: a Study of the Ordinary Observations in Comparison with the Photometric Observations of Harvard.* *By* Professor R. A. Sampson.

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5. *Solar Prominences and Terrestrial Magnetism.*[1]
By the Rev. A. L. Cortie, *S.J.*, *F.R.A.S.*

The bearing of recent researches by Father Sidgreaves, Dr. Chree, and the writer upon the question of the relation that exists between sun-spots and terrestrial magnetism has been to emphasise the general connection of the phenomena, but to disprove any connection of efficient cause and effect. The results of the

[1] Published in full in the *Astrophysical Journal*, November 1903.

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inquiries are more consistent with the existence of a common cause, which affects the sun and the magnets on the earth. The question, however, was raised some time since by Professor Garibaldi, and more recently by Sir Norman and Dr. Lockyer, as to whether prominences may not supply the place of sun-spots in those cases in which a great magnetic storm is unaccompanied by any spot. The curve of frequency of great magnetic storms is exactly coincident with that of solar prominences in high latitudes; also, sun-spots do not occur in such latitudes. Hence it would seem that to prominences should be attributed a special efficacy in the causation of magnetic storms. But it may be argued, in the contrary sense, that this coincidence is due to the fact that at times of solar-spot maximum activity the disturbance on the sun is general, and extends to greater distances from the actual regions of the spots, both prominences and coronal streams moving to higher latitudes with the advance of the sun-spot cycle. Moreover, it is known that the profile area of prominences, and their curve of frequency, conforms to that of sun-spots. Hence it would appear that prominences cannot in general be isolated from sun-spots as phenomena which are particularly active in influencing terrestrial magnetism. But the question still remains whether particularly large and violently eruptive prominences may not be effective in causing magnetic storms in the absence of spots. The only method of answering this question would be to make a detailed study of individual prominences that are in any way noteworthy, and of the magnetic storms, to see whether any such relationship subsists. As a contribution to such an investigation, two years have been dealt with, for which very full observations of prominences have been published by Father Fenyi, of Kalocsa, with detailed accounts of the larger and more noteworthy eruptions. The years 1887–88 were also years of minimum sun-spots, so that it would be easier to trace the connections, if any, which might exist between prominences and magnetic storms in the absence of spots. A list of forty-eight prominences was made from the observations, which were either violently eruptive or distinguished by great displacements of spectrum lines in the line of sight, or attained a height of over 100″. It was found that twenty-nine of these were either immediately associated with spots or faculæ, or occurred in the spot-zones, this class including all the metallic prominences. As regards the magnets, the maximum diurnal range of the declination was measured in each case from the Stonyhurst curves. On only one of the dates on which a high prominence was observed was there a magnetic storm, and, allowing three days before and after each observation of a prominence, there were only nine active disturbances of the magnets which occurred during such periods. In no single case can a magnetic storm be with certainty associated with any given prominence, and great prominences have occurred, with very large displacements of lines and violently eruptive activity, without any answering swings of the needles. As with the spots, so too with the prominences, the efficiency in the causation of magnetic storms, if such exists, is exerted irregularly and capriciously. It is the general disturbance of the sun and his surroundings which affects the earth's magnetism, and not any particular manifestation of spot or prominence.

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6. *Comparison of the Spectrum of Nitrogen and of the Aurora.* *By* Dr. A. Paulsen.

On m'a fait l'honneur, pendant mon séjour ici, de me demander de vouloir présenter à la Section d'Astronomie et de Météorologie de la British Association une photographie d'un spectre de l'aurore polaire que l'expédition danoise pour explorer l'aurore polaire a pris pendant son séjour dans le nord d'Islande dans l'hiver 1899–1900.

Avant de vous montrer cette photographie je pense que peut-être il pourrait être utile de faire quelques remarques sur la méthode et les instruments que nous avons employés et du caractère en général du spectre.

Sur ma demande le gouvernement danois m'a donné des moyens pour explorer

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l'aurore polaire, phénomène qui pendant mon séjour au Groenland, il y a maintenant 20 années, a attiré mon plus vif intérêt.

Quant au bout de ces recherches, l'examen du spectre de l'aurore polaire était une recherche du premier ordre. La zone où se développe les phénomènes auroraux dans leur plus grande fréquence, leur plus grande intensité et richesse de forme est loin des observatoires où on s'occupe des recherches spectrographiques des phénomènes célestes. L'apparition d'une aurore y est un phénomène rare, et l'apparition d'un tel phénomène pendant quelques heures d'une seule nuit, sous les latitudes moyennes, ne satisfait pas pour faire des recherches photographiques de son spectre. Excepté pour la ligne jaune-verdâtre découverte par Ångström, les longueurs d'onde des autres lignes ne sont pas bien déterminées par des recherches avec un spectromètre à vision directe. Et cela se comprend. Ce n'est que la ligne principale qu'on voit toujours quand une aurore apparaît; aussi la longueur d'onde de cette ligne est-elle exactement déterminée. Les autres lignes, au moins celles qui apparaissent dans la partie lumineuse du spectre, ne se voient pas toujours. Toujours très faible elles n'apparaissent généralement que dans quelques moments pour bientôt disparaître. Aussi la détermination de leurs longueurs d'onde diffère tant qu'on pourrait être porté à croire que les différentes aurores présentent des spectres différents.

A peu près d'un an avant mon départ pour l'Islande M. le professeur Pickering en Amérique avait trouvé par voie photographique deux ou trois lignes dont la plus intense avait une longueur d'onde de 390 m. environ. M. Pickering n'avait pas employé pour ses recherches un spectrographe construit particulièrement dans ce but, ce qui me donna un bon espoir pour mes recherches avec des spectrographes construits particulièrement pour la lueur de l'aurore polaire.

Comme spectrographes je me suis servi de deux appareils. Dans l'un des spectrographes le prisme était en spath d'Islande et les lentilles, non-achromatiques, en quartz. Je dois aux bons conseils de M. Mascart la bonne construction de cet appareil. C'est sur la proposition de M. Mascart qu'on a employé un prisme de spath d'Islande, qui a un grand pouvoir dispersif. Aussi M. Mascart a-t-il trouvé d'être bon d'employer des lentilles de quartz non-achromatiques pour éviter la perte de lumière provoquée par la réflexion des surfaces des deux lentilles. Puisque je ne me suis pas préparé à Copenhague à faire une lecture dans une des séances de l'Association Britannique je ne puis vous donner la mesure exacte de la longueur focale de la lentille du collimateur et de celle de l'objectif de la lunette. La longueur focale est la même pour ces deux lentilles, de sorte que l'image de la fente est de même grandeur que celle de la fente elle-même.

Nous nous sommes aussi servi d'un autre spectrographe construit par M. Scheiner de Potsdam. Les lentilles et le prisme de cet appareil sont d'un flint très pur. Le spectrographe de M. Scheiner a une puissance lumineuse plus grande que celui de l'autre appareil. On peut avec ce spectrographe photographier des lignes jusqu'à une longueur d'onde aux environs de la ligne O dans le spectre solaire. Je profite de l'occasion pour remercier encore M. Scheiner pour cet excellent appareil. Avant mon départ de Copenhague je n'osais pas à me fier seulement à un spectrographe à lentilles de quartz, à cause du diamètre nécessairement très petit des lentilles. Heureusement tous les deux instruments nous ont fourni de bons résultats.

Les appareils étaient construits de sorte qu'on pouvait toujours diriger par viser la fente du spectroscope contre le point du ciel où l'aurore se manifesta avec la plus grande intensité. Pendant les nuits à aurore on était donc toujours occupé à tourner le spectromètre. En outre on examinait le spectre des aurores qui apparaissent aux diverses parties du ciel avec un petit spectroscope de poche, pour voir dans quelles parties de l'aurore se montraient le plus grand nombre de lignes.

La première fois que nous exposâmes les instruments pour prendre des photographies de l'aurore fut au noël de 1899. Après une longue série de jours à mauvais temps venait une nuit à ciel pur; par conséquent nous posâmes les instruments sur place, les fentes ouvertes. Mais on n'aperçut toute cette nuit aucune aurore proprement dit. Vint ensuite une série de jours à neige; les

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instruments, qui étaient toujours posés sur un pilier en plein air, furent couverts d'une caisse. Quand au courant d'une semaine le temps ne s'améliora pas nous nous estimions pour bon de remplacer les plaques avec de nouvelles. Notre surprise fut donc grande en développant les plaques d'apercevoir quatre lignes dont les deux étaient découvertes déjà par M. Pickering, les deux autres étaient des lignes nouvelles. Les longueurs d'onde de ces quatre lignes étaient de 426 m., 391 m., 357 m. et 336 m. environ. On les mesurait par le micromètre de la lunette du spectrographe en comparant leur position avec celle des lignes de comparaison du spectre de l'air et de quelques métaux. La ligne de la moindre longueur d'onde n'était pas provoquée par le spectroscope à lentilles et prisme de flint, et la ligne d'une longueur d'onde de 336 m. n'apparaissait que comme une ligne très faible dans le spectre appartenant à ce dernier instrument.

Cette provocation inattendue d'un spectre photographique de l'aurore polaire nous frappa surtout parce qu'on n'avait aperçu aucune aurore, si ce n'était que des traces très fugitives d'une telle pendant la seule nuit claire dans laquelle les appareils étaient exposés. Le spectre provoqué par le spectrographe à lentilles de quartz et à prisme de spath d'Islande montra en outre une particularité remarquable, savoir celle qu'on avait obtenu par réflexion dans les deux prismes aux bouts de la fente une continuation des lignes qu'on avait obtenues par les rayons qui avaient entré immédiatement à travers la fente. Mais cette nuit le ciel était d'une clarté particulière qu'on ne connaît que dans les nuits arctiques. Aussi au Groenland, où j'ai passé un hiver comme chef de la station internationale polaire danoise, au milieu de l'hiver, dans les nuits où il n'y avait pas de clair de lune, le ciel paraissait souvent illuminé d'une lueur faible qui permettait de voir les montagnes à une distance de 30 kilomètres: dans ces circonstances on pouvait discerner de petites pierres sur le sol. Cette lumière de la nuit arctique fait un contraste remarquable aux ténèbres des nuits sous les latitudes basses. Quand, dans ces circonstances, on dirige le spectroscope vers le ciel on voit la ligne principale de l'aurore polaire. Cette clarté semble donc être la manifestation d'une aurore qui ne se montre que comme une lueur faible repartie sur la plus grande partie du ciel.

Les quatre lignes surnommées semblent paraître toujours quand il y a un phénomène auroral. La première de ces lignes, d'une longueur d'onde de 426 m., est située dans la partie violette du spectre de l'aurore; les autres appartiennent à la partie ultra-violette.

Dans la suite nous avons photographié en tour 21 lignes du spectre dont les 16 étaient inconnues jusque-là. Hors la ligne jaune-verdâtre d'Ångström nous n'avons pas pu photographier des lignes d'une longueur d'onde moindre que de 470 m.

Le temps mauvais pendant notre séjour en Islande, l'abondance des nuages et le clair de lune empêchaient en haut degré la suite de nos expériences, de sorte que les spectrographes ont été exposés un temps d'un mois à peu près pour recevoir la quantité de lumière nécessaire pour la photographie des lignes faibles.

En photographiant le spectre de la lumière bleue-violette qui entoure la cathode d'un tube Geissler rempli de nitrogène nous avons constaté une identité complète entre les lignes de la partie du spectro-auroral que nous avons photographié, sauf la ligne d'Ångström, et les lignes correspondantes dans le spectre cathodique de nitrogène. Pour mieux constater cette identité j'ai, à mon retour de l'Islande, demandé à M. Scheiner de Potsdam de vouloir faire des mesures comparatives des deux spectres avec les instruments de mesure excellents qui sont à sa disposition. Le résultat des mesures de M. Scheiner constate parfaitement le résultat que nous avons déjà trouvé en Islande. Ses deux spectres qui ont été pris par le même appareil avaient une dispersion une peu différente. En réduisant le spectre de l'aurore à la même disperaion que celle du spectre de la lumière cathodique les mesures de Scheiner démontrent une identité complète entre les deux spectres. (Voir 'Bulletin de l'Académie Royale des Sciences de Danemark,' 1901.)

Je vais maintenant vous montrer par projection une image des deux spectres susnommés. On voit sans faire des mesures que la répartition des lignes des deux

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spectres est la même. Dans le spectre cathodique vous voyez une ligne assez forte dont la longueur d'onde est de 317 m. environ. Cette ligne ne se trouve pas dans le spectre de l'aurore polaire. Mais dans l'hiver 1900–1901 M. la Cour, qui a fait toutes les photographies spectrales en Islande, a trouvé cette ligne pendant un séjour en Finlande.

Le spectre que j'ai l'honneur de vous avoir montré n'est pas le spectre complet de l'aurore ; nous n'avons pas pu photographier des lignes dans la partie des spectres dont la longueur d'onde est situé entre $\lambda = 557$ m. et $\lambda = 470$ m. La nature de la ligne principale d'Ångström a été inconnu jusqu'à ce dernier temps. Vous savez que M. le professeur Ramsay, qui a découvert lui-même le crypton, a constaté qu'une des lignes de cet air coïncide parfaitement avec la ligne d'Ångström.

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7. *Discussion on Kite Observations continued.*

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8. *Diurnal Range of the Summer Temperature of the Levant.* By Alexander Buchan, *LL.D., F.R.S., F.R.S.E.*

One of the best portions of the sea in which the effects of insolation and nocturnal radiation on the temperature can be most satisfactorily investigated is the Levant during the summer months, it being there and then that the sky is cloudless, or all but cloudless, the air very dry, with little or no rain, and calms or light winds prevalent, from approximately the same direction.

It was under such favourable conditions that the four magnificent series of serial temperatures were made in the summers of 1890, 1891, 1892, and 1893 respectively, by the Austrian ship 'Pola,' in the eastern half of the Mediterranean, at various depths from the surface of the sea to the bottom. These have been published *in extenso*, together with the rest of the deep-sea work carried out by the 'Pola,' in the 'Transactions of the Imperial Academy of Sciences of Vienna.'

The thermometers and the other instruments used for salinity, colour of sea, &c., were the best that could be procured, and nothing but the highest praise can be passed on the methods employed and the skill with which the observations were carried out and printed.

With the temperature observations are also published the hours of the day at which they were taken, and at the same time the temperature and pressure of the air, the amount of cloud, and the direction and force of the wind. Hence a novel and notable addition to science accompanies these observations, viz. the time of day at which they were made. In truth this observation of time invariably recorded throughout the four summers presents us with the means of arriving, for the first time, at a knowledge of the depth to which the sun's heat penetrates so as to affect the temperature of the water, and also the amount of daily variation brought about at different depths up to the surface by solar and nocturnal radiation.

To carry this out two tables were constructed. One table showed the observations made at those hours of the day which may be regarded as showing the effect of insolation, and the table for the observations at the hours which may be regarded as showing the effect of nocturnal radiation. The hours for insolation were from 2 to 6 P.M., and the hours for nocturnal radiation in the morning till 9 A.M., the mean time of the fifty days for insolation being from 3.14 to 4.30 P.M., and of the fifty days for nocturnal radiation being from 6.30 to 7.45 P.M. In any one of these 100 cases the least depth of the sea at the place where the serial temperatures were recorded was 419 metres, but generally the depth much exceeded this figure, the depth in any case being 4,400 metres.

For the fifty P.M. observations the mean position was 35° 29′ lat. N. and 26° 24′ long. E.; and for the fifty A.M. observations 35° 35′ lat. N. and 26° 31′ long. E. Hence the geographical positions were virtually identical, and on no particular day was there any material difference between the two positions.

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The following are the mean meteorological observations for the days of the two sets of serial observations respectively:

	P.M.	A.M.
Mean temperature of air (F.)	82·3	78·4
„ Cloud (0–10)	1·6	1·7
„ Wind Force (0–12)	2·1	2·2
„ „ Direction N.	9	8
„ „ „ N.E.	2	4
„ „ „ E.	2	3
„ „ „ S.E.	2	0
„ „ „ S.	1	2
„ „ „ S.W.	6	4
„ „ „ W.	8	8
„ „ „ N.W.	18	18
„ „ „ Calms	2	3

The temperature of the air at the time of the afternoon observations was 82°·3, and in the morning 78°·4, the difference, about 4°·0 higher, being nearly the average difference at these times of the day of the temperature of the air over the ocean where the climate is similar. The amount of cloud in the morning and evening is virtually the same, and indicates that the observations were taken under a sky having only a sixth part covered with cloud. The force of the wind was also nearly the same, the mean force being just a little over 2 on the scale of 0–12, or, say, a light breeze, blowing at the rate of fourteen miles an hour. As regards the direction of the wind, observations show that nearly the whole of the winds at this season are west-north-westerly.

The following figures, showing the depths in feet and the temperatures (Fahr.), present the results of this inquiry in their simplest form:—

Depth of Sea. Feet	Observations		Difference
	Morning	Evening	
	°	°	°
0 (or surface)	77·4	78·8	1·4
3	77·2	78·6	1·4
7	77·1	78·4	1·3
16	76·8	78·1	1 3
33	76·5	77·4	0·9
66	75·0	75 5	0·5
98	71·6	71·9	0·3
164	65·5	65·4	−0·1
259	62·6	62·6	0·0
328	60·6	60·6	0·0

Hence in the summer months the sun's heat penetrates to a depth of about 150 feet. At the surface the temperature in the afternoon is 1°·4 higher than in the morning, and this difference virtually holds to a depth of 16 feet. At lower depths it gradually lessens to 0°·9 at 33 feet; 0°·5 at 66 feet; 0°·3 at 98 feet; and vanishes at about 150 feet. Next morning the temperature is lowered to what it was in the preceding morning, and so on from day to day, the loss during the night being compensated by an increase of temperature on the following day equal, depth by depth, to the loss during the night. Thus at each depth the gain of temperature from solar radiation is equal to the loss sustained by nocturnal radiation.

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9. *Progress of the Magnetic Survey of the United States.* *By* L. A. Bauer.

In 1899 it was my privilege to lay before this Association the plan, in accordance with which a detailed and systematic survey of the United States had just

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been inaugurated. This plan, in brief, was to first make a general survey with stations about 25–30 miles distant from one another, and to occupy about 400–500 stations a year. After the general survey had been completed, additional stations were to be placed in the locally or regionally disturbed areas developed by the general survey. On the average there was to be a 'repeat' station for an area of ten stations. A period of ten to fifteen years was expected to be consumed in the general survey. The area to be surveyed, not counting the adjacent seas, embraces one-fifteenth of the entire land area of the globe, or an area equal to that of Europe.

Up to June of the present year nearly one-third of the total number of stations contemplated for the general survey, viz. about 1,250 stations, have been completed. Five magnetic observatories have been established—Cheltenham (Maryland), Baldwin (Kansas), Sitka (Alaska), Honolulu (Hawaiian Islands), and Vieques Island (Porto Rico). A sixth is contemplated for the north-western part of the United States. In addition, a variety of miscellaneous preliminary investigations relating to methods of work and reduction and the standardisation of instruments have been made, and several publications have been issued. During this year magnetic work at sea has been commenced on board the vessels of the Coast Survey. The reduction of the field work has been kept apace with the observational work, so that the results obtained during any one year are published within a few months after the close of the year.

With the successful completion of the arduous initial work attendant upon the inauguration of so vast a magnetic survey, and the systematisation of the various operations in the field and in the office, and having trained the necessary observers, we may look forward to the continuation of the work with even greater rapidity than that of the past four years, and it is confidently believed that the general magnetic survey will be completed at about the close of the present decade.

I shall again express the hope that Canada may soon be able to follow the example of the United States.

The chart exhibited shows the number and positions of the magnetic stations in the United States up to June 30, 1903.

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10. *The Earth's Total Magnetic Energy.*[1] *By* L. A. Bauer.

WEDNESDAY, SEPTEMBER 16.

The following Papers and Report were read:—

1. *A Probable Relationship between the Solar Prominences and Corona.* *By* William J. S. Lockyer, *M.A., Ph.D., F.R.A.S.*

This Paper has already appeared in the 'Monthly Notices of the Royal Astronomical Society' (vol. lxiii. No. 8, 1903). The object of the investigation is to suggest that the different forms of the corona are intimately connected with the latitudes of the prominences. A summary of the conclusions arrived at is as follows:—

1. The 'forms' of coronas may be grouped generally into three classes, here named 'polar,' 'intermediate,' and 'equatorial,' according as the streamers appear near the solar poles, in mid-latitudes, or about each side of the equator.

2. The sequence of these forms, if sufficient numbers of eclipses occurred, should be equatorial, intermediate polar, intermediate equatorial, &c.

3. The various forms of the corona are closely connected with the positions (as regards latitude) of the centres of action of the solar prominences.

[1] Published in full in *Terrestrial Magnetism*, September 1903.

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4. The coronas of the 'polar' or 'irregular' type occur about the times when the prominences are most abundant near the solar poles.

5. The 'equatorial' coronas when there is *one* centre of prominence action (about latitude ± 45) in each hemisphere.

6. The 'intermediate' type is produced by *two* centres of prominence action in each hemisphere, but neither centres near the poles.

7. The peculiar 'arched' form of some streamers is produced by the action of two zones of prominences situated near the extremities of their base.

8. Sun-spot activity has apparently no *direct* connection with the production of the coronal streamers.

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2. *Report on Meteorological Observations on Ben Nevis.*
See Reports, p. 56.

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3. *Electrical Self-recording Instruments.*
By Professor H. L. CALLENDAR, *F.R.S.*

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4. *Effect of Meteorological Conditions upon Audibility.*
By A. LAWRENCE ROTCH, *B.S., M.A.*

Notwithstanding previous investigations on this subject, the opportunity to determine the variable influence of a stratum of air 600 feet thick, having a meteorological station at the bottom and the Blue Hill Observatory at the top, caused the writer to institute daily observations of audibility during the year 1901.

The source of sound employed was a steam whistle, distant 2·7 miles on the plain, which was blown twice a day, and the intensity of the sound at the Observatory estimated on a four-part scale.

The observations were discussed on the hypothesis that variations in the intensity of sound are caused by vertical differences in wind-velocity or in temperature and moisture. It is found that differences of temperature and relative humidity between the two stations had no appreciable effect on the audibility, but that the variations observed in it could be explained by the action of winds increasing in velocity with altitude at a known rate, which tilted the sound-wave over the Observatory when the wind was opposed to the sound, and kept it from rising high above the ground when the wind blew from the source of sound. Nearly equal audibility was found for winds blowing at right angles to the above, a phenomenon that was explained by the late Sir G. G. Stokes to the British Association in 1857.

Measurements of the velocity of the sound, corrected for the temperature of the air, showed an acceleration in winds blowing from the whistle to the observer which approximately equalled the known speed of the air stratum. This investigation will be published in the 'Annals of the Astronomical Observatory of Harvard College,' vol. xliii. Part III.

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5. *On some Rainfall Problems.* *By* HUGH ROBERT MILL, *D.Sc., LL.D.*

In attempting to ascertain the distribution of mean rainfall over a large area it is necessary to make allowance for the unequal height of the receiving surface of the rain-gauges above the ground, for the irregular distribution of rain-gauges over the country, and for the different lengths of the records from the various stations. When the object is to ascertain the distribution of rainfall for any given day or month, the hour of reading the rain-gauge and the method of entering the result have to be ascertained, and varying methods adjusted to a common standard. The determination of the distribution of rainfall for a given year involves less

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uncertainty, as any difference of hours of reading or date of entering is proportionally smaller.

In the special case of charting the annual rainfall of the British Isles for a given year the most serious difficulty is the absence of observations from certain areas; in charting the mean rainfall the further difficulty is superadded of the unequal duration of the records. Various methods of overcoming these difficulties are put forward, and maps exhibited showing the distribution of rain-observing stations at work in 1902 in England and Wales, Scotland and Ireland.

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SECTION B.—CHEMISTRY.

PRESIDENT OF THE SECTION—Professor WALTER NOEL HARTLEY, D.Sc., F.R.S., F.R.S.E.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

THE ofttimes laborious method of investigating the relationship of substances by ascertaining how one form of matter can operate upon another, in other words by chemical reactions, has of late been supplemented by the examination of their physical properties, and has been extended to compounds, both organic and inorganic. In several directions this has led to results of very uncommon interest. Accordingly I propose to offer a brief account of twenty-five years' experimental work in that branch of chemical physics which deals with the emission and absorption of rays of measurable wave-length, and to review its present position chiefly in relation to the theory of chemistry, indicating where it may be usefully and profitably extended.

According to Davy,[1] Ritter observed chemical action on moist chloride of silver to be different in different parts of the spectrum, slight in the red, greater towards the violet, and extending into a space beyond the violet where there is no sensible light or heat. Wollaston discovered that chemical action was exerted by refracted rays in a region where they were of a higher refrangibility than any rays that were visible. Young showed that the invisible rays are liable to the same affections as visible rays. Hence we have the beginnings of spectrum analysis in its chemical relations to terrestrial matter, in the infra-red, the visible, and the ultra-violet regions.

Everyone is more or less familiar with the subject of spectrum analysis. This was defined by Tait as an optical method of making a diagnosis of the chemical composition of either (*a*) a self-luminous body, or (*b*) an absorbing medium, whether self-luminous or not. It has now become necessary to enlarge this definition, and I would suggest that it is the study of the composition and the constitution of matter by means of radiant energy, and recording in the order of their refrangibilities the rays emitted and absorbed by matter. By this modified statement the infra-red or so-called 'invisible heat rays,' the visible or 'colour rays,' and the ultra-violet or 'chemical rays' are included.

Spectra are of two kinds, emission and absorption spectra. It will be convenient if the latter are considered first.

ABSORPTION SPECTRA.

The Infra-red Region.

Abney (1880) by the preparation of a particularly sensitive form of collodion emulsion containing silver bromide was successful in obtaining very extraordinary results. Such films as he prepared were so sensitive to invisible radiations of long wave-length as to be capable of forming a representation of even a kettle of

[1] *Chemical Philosophy*, vol. i. 1812, p. 211.

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boiling water, standing in an absolutely dark room. This picture could not of course be properly referred to as a photograph, though the process by which it was obtained was such as we are accustomed to term a photographic process. It may with greater propriety be termed an actinograph, the result not of light, but of dark rays. The least refrangible of the visible rays lies about wave-length 7,800 ten-millionths of a millimetre, or Ångström units; but these rays extend as far as wave-length 12,000, while Becquerel has measured lines in the spectra of metals of as low a refrangibility as wave-length 18,000.

Abney and Festing (1881) investigated the influence of atomic groupings in the molecules of organic substances by measuring their absorption in the infra-red region of the spectrum.

They studied such simply constituted substances as water, hydrochloric acid, chloroform, carbon tetrachloride, and cyanogen, besides many hydrocarbons with their hydroxyl, haloid, and carboxyl derivatives. Characteristic groups of lines or very narrow bands were observed in carbon compounds, but they are absent from carbon compounds, containing no hydrogen, and do not all appear in some of the hydrogen compounds. The facts observed led to the conclusion that they belonged to hydrogen, but are subject to some occasional modifications. Oxygen in hydroxyl, for instance, modifies two of the lines, since it obliterates by absorption the rays which lie between them. Oxygen in aldehyde, or when it forms part of the carbon nucleus of some such compound, presents bands which are bounded by well-defined lines, or are inclined to be linear. These appear to be characteristic bands indicating the carbon nucleus of a series of substances. Alkyl radicals, such as ethyl, exhibit absorption bands, and so does the benzene nucleus. It is a remarkable fact that bands appear in the solar spectrum which correspond with those of benzene (1881).

Julius (1893) has investigated the absorption in the infra-red caused by many carbon compounds by means of the bolometer, combined with a prism, and also with a diffraction grating. He showed that the molecules of compound substances absorbed the rays which were emitted at the time of their formation. Thus, to take the simplest case, the emission spectrum of hydrogen burning in air corresponds with the absorption bands of water vapour, that is to say, the absorption spectra of the compounds are the counterpart of the emission spectra of the flames which yield these compounds during combustion. The emission spectrum of carbon dioxide is found in the spectrum of burning carbon monoxide, cyanogen, methane, and carbon disulphide; and that of water-vapour in various hydrocarbons. As early as 1888 Julius, in an Inaugural Dissertation, quoting Tyndall, recognised that the absorption and emission of rays measured with the thermopile were manifestations of the molecular vibrations.

The various absorption spectra examined included those of the alcohols, such as isopentylic, isobutylic, normal butylic, propylic, ethylic, and methylic, as well as hydrocarbons, chloroform, and benzene. The study of the maxima of radiation and the maxima of absorption offers us a means of arriving at a knowledge of a series of new and valuable physical constants, namely, the vibration periods characteristic of the molecules. (Tyndall discussed this subject in his usually luminous style on pages 391 to 402 of his work 'Heat as a Mode of Motion.')

Puccianti (1900) has examined the infra-red absorption spectra of liquids, including aromatic compounds and alkyl derivatives, while Donath has examined in the same region various essential oils. Carbon combined with hydrogen shows a maximum of absorption with a wave-length about (1·71 μ mm.) 17,100 Ångström units.

Benzene and pyridine have two other maxima of absorption in common. The alcohols have very similar maxima of absorption at wave-length 21,000.

The three isomeric xylenes show absorption spectra which are almost identical. At or about wave-length 23,200 another maximum of absorption is shown.

Julius refers to Langley's observation that at a wave-length of 27,000 there is an abrupt termination to the solar spectrum, probably caused by the water vapour in the atmosphere; but a band extends to 273,000, and at no very great elevation above the earth's surface there are rays with a wave-length of 45,700 Ångström

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units. All radiations of longer wave-length—and Julius has measured down to 149,000 Ångström units—are likely to be absorbed by the carbon dioxide in the atmosphere.

The Visible Rays or Colour Region.

J. L. Schönn (1879) examined the absorption spectra of substances usually considered to be colourless in layers from 1·6 to 3·7 metres in thickness and observed narrow bands in the spectra of methyl, ethyl, and amyl alcohol, lying in the red, orange, and yellow; methyl alcohol showed two bands, ethyl and amyl alcohol each three. Gerard Krüss (1888) calculated the wave-lengths of these bands, and it appears that the higher members of the homologous series have the bands displaced towards the red end of the spectrum. Russell and Lapraik (1879) made similar observations on columns of liquid from two to eight feet in length. All the substances gave well-defined absorption bands lying between wave-lengths 6,000 and 7,000.

The bands of the different substances differed altogether from the bands of water. Alcohols give a band which is similar in different alcohols, but the higher the alcohol stands in the homologous series, that is to say, the larger the number of carbon atoms it contains, the nearer is the band to the red end of the spectrum (1881).

It was definitely established that for each CH_3 introduced into a molecule of ammonia or benzene there is a shifting of the absorption bands towards the red end of the spectrum.

It will, of course, be understood that the liquids examined were perfectly colourless in the ordinary acceptation of the term; and that they appear so is owing to the bands of absorption being very narrow, so that the percentage of luminous rays withdrawn by absorption is but a very small fraction of the whole spectrum emitted by a source of light when viewed under ordinary conditions.

Numerous observations were made by Melde, Burger, Magnus, H. W. Vogel, and Landauer (1876–78), which showed that changes in the absorption spectra of solutions are partly physical and partly chemical, that is to say, they are caused by changes in the constitution of the solution. Vogel mentions cases where no chemical change was believed to take place, as, for instance, where naphthalene red shows different spectra according to whether it is dissolved in alcohol, water, resin, or is solid or used to colour paper (1878).

This points to some difference in the constitution of the solution. A well-known instance is that of iodine in alcohol, chloroform, or carbon disulphide.

It must be observed that Vogel's work referred merely to phenomena observable in the visible spectrum, to small thicknesses of the absorbing medium, and was not applied quantitatively. Two solutions may give spectra which are apparently identical at one concentration, but spectra quite different when submitted to varying degrees of dilution.

In order to ascertain in what way absorption spectra are related to the chemical constitution of organic substances, it is necessary to examine a wider range of spectrum than that included in the merely visible region, and this may be done by extending the observations into the ultra-violet.

The Ultra-violet Region.

Stokes in preparing his experiments for a Friday evening discourse at the Royal Institution observed that the spectrum of electric light when a prism and lenses of quartz were used extended no less than six or eight times the length of the visible spectrum. In 1862 he studied the ultra-violet spectra of metals and executed drawings of the lines exhibited by aluminium, zinc, and cadmium. He discovered the fact that certain solutions show light and dark bands in the spectrum of rays transmitted by them, the solutions being colourless; the bands are invisible unless they fall on a fluorescent screen. It was under such conditions

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that they exhibited light and darkness. The screen used was of plaster of Paris saturated with a fluorescent substance, such as uranium phosphate.

William Allen Miller in 1863, simultaneously with Stokes, described his method of examining the photographic transparency of various saline solutions and organic substances and of depicting metallic spectra. A sensitised photographic plate was used for the reception of the rays of the spectrum, so that they were made to register their own position and intensity. L. Soret invented the fluorescent eyepiece for the purpose of investigating the ultra-violet rays and ascertained the best media for the transmission of rays of high refrangibility. Colourless fluor-spar, a rare mineral, was found to answer best, and quartz lenses were achromatised with this. Iceland spar was found to absorb some of the more refrangible rays, and a pure spectrum was difficult to obtain with quartz prisms owing to double refraction, which caused the lines in metallic spectra to be duplicated. Struck by the fact that Miller had examined many organic substances without obtaining evidence of a connection between their constitution and their absorption spectra—the actual words used by Miller were, 'I have not been able to trace any special connection between the chemical complexity of a substance and its diactinic power'[1]—it appeared to me desirable that this point should be systematically reinvestigated. L. Soret had already proceeded with work in this direction, by examining and drawing a great variety of organic substances and diagrams of absorption curves. But it was deemed necessary to make a large number of examinations of substances of a comparatively simple constitution, and according to theory closely related, and afterwards gradually to proceed to the study of substances of greater complexity. For such purposes a photographic method alone appeared a practicable one, particularly when comparisons had to be made between substances observed at different times, for the reason that none but photographic records could be absolutely relied upon and stored away for future reference.[2]

The plan of the proposed investigation was to photograph the rays transmitted by molecular proportions of hydrocarbons, alcohols, acids, and esters, either alone as vapour or liquid, or dissolved in some neutral and, in comparison with the substances to be examined, an optically non-absorbent solvent.

[1] *Journ. Chem. Soc.* vol. xi. p. 68.

[2] Clerk Maxwell had calculated for Miller the best focal length of lenses of quartz which would give an approximately flat field. His computation made this something over a length of three feet. All Miller's photographs were taken with the plate placed normal to the axis of the lens, but Stokes had shown that the locus of the foci of the different rays formed an arc of a curve or nearly a straight line, lying very obliquely to the axes of the pencils coming through the lens.

It was obvious from Miller's photographs that only one or two rays on each plate were even approximately in focus. To obtain spectra in focus from end to end it was evidently necessary to incline the plate so that the end upon which the red rays would fall, which are of longest wave-length, should be farther off than that upon which the ultra-violet fall which are of shortest wave length. It was also found experimentally that lenses of much shorter focal length (ten or twelve inches) could be used, giving perfect definition, and, what is still more important, it was found a positive advantage not to have them corrected by fluor-spar or calcite. The plate carrier was adjusted at an inclination of approximately 22° to the normal; in such a position the rays from the yellow sodium line to the extreme ultra-violet of the spark spectrum of cadmium were simultaneously in focus on a plane surface.

The prism was of quartz cut on Cornu's plan, the method of construction designed to get rid of all double refraction being communicated to me by M. Cornu in a very kindly written letter. The first instrument was constructed in 1878 and the description of it published in 1881. It has been the model for several others. One with two prisms and lenses of 12 inches focus was exhibited by me in the Inventions Exhibition in 1882. At the Jubilee meeting of the British Association at York the spark spectra of iron, cobalt, and nickel, enlarged to twenty-five diameters and printed by the Autotype Company, were exhibited. They are over eight feet in length, and have proved very useful for reference. The photographic process is a point of great importance; the then newly invented gelatine bromide films made by Kennet were alone quite suitable.

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It was considered that the metameric esters would afford much information if a sufficient number of them were examined and their spectra compared, and if the acids themselves were not responsive the sodium and potassium salts in solution would serve the purpose, since the alkalies did not affect the spectrum. The general deductions (1879) are now well known, but two points not generally taken into account were well established. First, the extraordinary delicacy of the ultra-violet spectrum in detecting traces of impurities. For instance, pyridine, an invariable impurity in commercial ammonia, is present in the proportion of about $\frac{1}{50000}$th. It was proved that the absorption spectra of the normal paraffins prepared with the greatest care by Schorlemmer contained traces of impurities which could not be separated. Secondly, some of the normal alcohols could not be rendered pure by the ordinary methods employed, and great care was necessary in their preparation. It may well be asked that, if such were the case, upon what grounds was it concluded that impurities were present? How was it possible to distinguish between a normal and an abnormal absorption spectrum when no standards of comparison existed? It may be of interest if this question be now answered, as no adequate account of it has been made public. All the substances in any one homologous series were shown to vary in the extent to which the rays at the more refrangible end of the spectrum were absorbed, and the different terms of the series differ solely by the number of CH_2 groups in the molecule; and the greater the number of these the greater the absorption. The extent of the absorption should be proportional to the molecular weight of the substance. Accordingly if repeatedly purifying and fractionally distilling a considerable quantity of material failed to give spectra which were constant and identical, but gave instead spectra which were variable, even in a slight degree, it was evident that the absorption due to the molecule of the substance was interfered with by some impurity.

When, however, it became evident that successive quantities of methylic alcohol, for example, prepared in a certain manner yielded spectra which were practically identical under different conditions, such as thickness of liquid, and that they differed but slightly from that of pure water after the type of which the alcohol is constituted, the conclusion was inevitable that we were dealing with a pure preparation. In short, the longest spectrum obtained under all circumstances and under every reasonable condition could not possibly be the result of accident, more particularly if it could be repeatedly obtained from different specimens of the same substance. The same reasoning applies to the acids and their salts in the investigation of which similar difficulties arose.

Soret and Rilliet pointed out that in the rectification and prolonged desiccation of the alcohols there is often slight oxidation which leads to the production of impurities which affect the spectra transmitted by them.

They found that ethyl alcohol is not appreciably less diactinic than methyl alcohol, and both transmitted a spectrum nearly as long as that of water. This was shown by Huntington and me when the usual 25 mm. of thickness of the layer of liquid were tested. By taking columns of liquid 100 mm. in length the differences are greater, and they increase with columns of increased length.

The influence of each additional CH_2 in the molecule causes a shortening of the spectrum. This was shown to be due to the carbon atoms and not to the hydrogen. The acids, containing the same number of carbon atoms as the alcohols, have a much greater absorptive power, which is due to the carboxyl group (C : O · OH). By the examination of a number of various substances, such as polyhydric alcohols, as glycol, glycerol, mannitol, and various sugars, it was found that, no matter what its complexity, no open-chain compound causes selective absorption, *i.e.* absorption bands.

Shortly it may be stated that in the examination of organic substances we have three variations in absorption spectra: First, those of substances the rays of which are freely transmitted, the absorption being at the more refrangible end of the spectrum, and the spectrum of which is readily increased in length by dilution; secondly, those in which the spectra are of the same kind, but the absorptive power is greater, so that they withstand dilution to a much greater extent;

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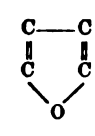
thirdly, those spectra which exhibit selective absorption, and which at the same time exert great absorptive power, or, in other words, can undergo great dilution before the absorption bands are rendered visible, and still further dilution before they are extinguished or obliterated.

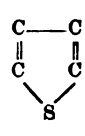
Spectra of the First Variety belong to substances which are constructed on an open chain of carbon atoms, thus: C · C · C · C · C or C≡C · C · C · C and C≡C · C · C · C.

The introduction in place of one or more atoms of hydrogen—of hydroxyl, OH, carboxyl, COOH, methoxyl, OCH_3, CO, COH, or NH_2, or of side chains such as CH_3, C_2H_5, &c.—does not affect the character of the spectra, but merely the absorptive power, which is increased when oxygen or an oxygenated radical is introduced.

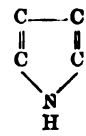
Spectra of the Second Variety are spectra of substances so constituted that the carbon atoms form a closed chain. It is immaterial whether the closed chains are homocyclic or heterocyclic; thus:—



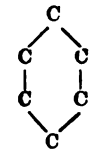
Furfurane.



Thiophene.

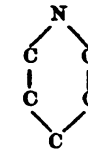


Pyrrol.

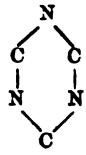


Diketohexamethylene

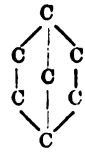
Hydroaromatic compounds.



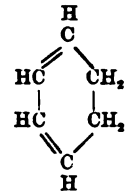
Piperidine.



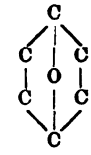
Cyanuric Acid



Camphor.



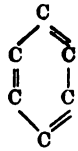
Dihydrobenzene.



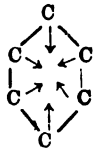
Cineol.

They possess greater absorptive power than open-chain compounds, but do not exhibit absorption bands. It is manifestly the chain or ring structure of the compounds that gives them greater absorptive power, and not the number of carbon atoms in the molecules.

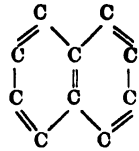
Spectra of the Third Variety.—These show absorption bands, and the substances yielding them are generally constituted on the type of benzene, naphthalene, anthracene, phenanthrene, &c.; but the rings may be either homocyclic or heterocyclic without the character of the spectra being altered; thus:—



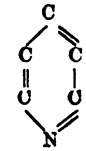
Benzene.



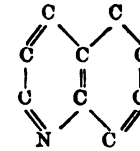
Benzene.



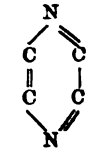
Naphthalene.



Pyridine.



Quinoline.



Pyrazine.

If we say that the compounds which are homocyclic are constituted of at least three pairs of carbon atoms doubly linked, which are themselves singly linked together, we may make use of the formula of Kekulé for benzene as the simplest expression of their constitution; if we assume that each of the six atoms is linked to at least other two atoms we adopt what is practically the prism formula of Ladenburg, or the same idea expressed in space of two dimensions. It is difficult to express the physical condition by the Armstrong-Baeyer formula or centric arrangement because this does not clearly suggest to one's mind what is manifestly the fact, namely, that the carbon atoms in the nucleus of benzene are much more

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closely condensed or combined together than those of the hydroaromatic series. This condensed condition of the carbon atoms is evident from the higher molecular refractive energy of aromatic compounds and of the specific refractive energy of the carbon in such combinations.

Side chains such as do not exert selective absorption have no influence on the character of the spectra, but they slightly increase the general absorption.

Heterocyclic compounds possess greater absorptive power, both as regards the general and selective absorption, than those which are homocyclic.

The point which I particularly desire to draw attention to here is, that for the first time Kekulé's remarkable benzene theory was supported by definite physical measurements, and the closed-ring formula represented a veritable actuality.

Of Molecular and Intra-molecular Vibrations.

Johnstone Stoney was the first to show that the cause of the interrupted spectra of gases is to be referred to the motions within the individual molecules, and not to the irregular journeys or encounters of the molecules with each other; and this applies to the absorption as well as to emission spectra. He further advised the use of oscillation frequencies instead of wave-lengths in describing the measurements of spectra. Johnstone Stoney and Emerson Reynolds subsequently examined the extraordinary absorption exhibited by chlorochromic anhydride, the bands in which are evidently harmonically related.

It has already been shown that the hydrocarbons of the aromatic series exert two kinds of absorption, a general and a selective absorption. All the evidence we possess warrants the belief that the general absorption is caused by the motion of the molecules, while the selective absorption is due to the motion within the molecules.

When the molecule of a substance is capable of vibrating synchronously with a radiation, the ray received on this substance is absorbed. The absorption is complete if the direction of the vibration of the molecule and of the ray is the same but the phase opposite, and if the number of molecules in the path of the rays is sufficient to damp all the vibrations.

When the quantity of substance in the path of the rays is reduced, the number of molecules present is not sufficient to damp all the vibrations and some of the rays are transmitted. If, however, certain carbon atoms within the molecule are vibrating synchronously with certain rays, we shall have selective absorption of these rays after the general absorption has been so weakened by dilution or otherwise as to allow them to pass.

It is evident, then, that general selective absorption exerted by carbon compounds is due to the vibration of the molecules because the absorption increases with the number of carbon atoms in the molecule; or, in other words, in any homologous series the greater the molecular mass the lower the rate of vibration of the molecule.

It has not been found possible to associate any of the absorption bands of the substances examined with any particular carbon atoms; but the bands in benzene are six in number, or the same in number as the carbon atoms. It has, however, been shown that the rapidity of the intra-molecular vibrations was dependent upon the rate of vibration of the molecules. From numbers representing approximately the mean wave-lengths of the four chief bands of rays absorbed by benzene, naphthalene, and anthracene, and from the velocity of light, the mean rate of the vibrations within the molecules was calculated (1881), the numbers being as follows:—

	Molecular Vibrations.
Benzene	1248^{10}
Naphthalene	1177^{10}
Anthracene	910^{10}

The mean rate of vibration of the rays absorbed by naphthalene is less than that absorbed by benzene, and those of anthracene less than those of naphthalene.

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It follows from this that the vibrations within the molecules are not independent, but are a consequence, of the fundamental molecular vibrations, like the harmonics of a stretched string or of a bell.

The term absorptive power has generally been used with respect to the extent of rays of the spectrum absorbed, but there is intensity of absorption to be considered. In the case of a vibrating string or tuning-fork greater amplitude of vibration means a louder note; in the case of molecules greater intensity of absorption may be caused by a greater amplitude of vibration in the molecules of the absorbing medium, the number of molecules being constant. But by greater amplitude it is not to be understood that the rate of vibration is increased.

If this be so then, as the absorption intensity of anthracene and naphthalene is, molecule for molecule, greater than that of benzene, the amplitude of vibration of the molecules of these substances is greater, but the rate of vibration is slower.

From the foregoing it will be observed that where λ is the wave-length $\frac{1}{\lambda}$ is the inverse wave-length, and, omitting the correction for the refraction of air which is a very small value, it is the oscillation frequency of the ether in a small unit of time, and the most convenient measurement for use in describing spectra. Seven years after the publication of these views Gerard Krüss (1888) dealt with the subject of coloured substances in a similar manner. From the undulatory theory of light, deductions may be drawn regarding the inner molecular movements or inter-atomic movements within the molecules, inasmuch as the vibrations of the ether, which fills the intra-molecular space, are a resultant within that space of the velocity and amplitude of the molecular vibrations.

Thus, if λ be the wave-length of a ray emitted by a substance, and v the velocity of light, the number of vibrations, n, which a molecule sends forth by movements of it as a whole and of its parts can by determined by the equation $n = \frac{v}{\lambda}$.

G. Krüss made a series of calculations for coloured substances similar to those which I had made for colourless substances and for ozone.

Curves of Molecular Vibrations.

Observations on absorption spectra should, whenever it is possible, be made with reference to the quantity of substance which produces a given measurable effect. A molecular weight in milligrams or a milligram-molecule is a convenient quantity which may be dissolved in 20 c.c., 40 c.c., or 100 c.c. of any non-absorbent liquid, and observed through thicknesses of the solution varying from 25 mm. to 1 mm. in thickness. When a series of photographs have been measured a curve is plotted, which shows the general and the selective absorption of the substance. The oscillation frequencies of the absorbed rays are taken as abscissæ, and the proportional thickness in millimetres of the weakest of a series of solutions as ordinates. The curves are as often as possible made continuous, and they are called *curves of molecular vibrations.*

The curves of the molecular vibrations present very striking features: they are valuable physical constants which enable one to classify and identify substances.

Position Isomerism.

Isomerides of the *ortho-*, *meta-*, and *para*-positions in aromatic substances yield spectra with the absorption bands, differing in position, in width, and in intensity. There is no distinguishing character to be observed in the different isomerides. Isomerism in the pyridine, quinoline, and naphthalene derivatives has not yet been completely studied. In such cases as have already passed under review there is nothing that indicates the positions of the substituted hydrogens.

Stereo-isomerism.

Where isomerism is not due to differences in structure, but simply to the distribution of the atoms in space, we have no means of distinguishing isomeric

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substances from an examination of their spectra; for instance, benz-*syn*-aldoxime and benz-*anti*-aldoxime yield curves of molecular vibrations which are identical.

Tautomerism.

The possibility of an atom of hydrogen occupying alternative positions in a compound

$$(NH \cdot C : O \rightleftarrows N : C \cdot OH)$$

so that it may be united to an atom of nitrogen or of carbon in one instance, or to an atom of oxygen in another, easily gives rise to substances with different characters, the one that of a phenol, the other that of a ketone. One interpretation of the facts observed which has been very commonly received may be stated thus. Certain compounds have in their constitution an atom of hydrogen of a 'roving disposition' which at one time will attach itself to an atom of oxygen, or to an atom of nitrogen, and anon it will forsake one of these and unite itself to an atom of carbon. The consequence of this 'instability of character' is that when a derivative of the compound is being prepared or sought for by a chemical process, which according to all previous knowledge ought to yield it, the substance brought forth is of a different class, but withal of the same composition; it is, in fact, an isomeride.

According to another theory, the two isomeric derivatives of the parent substance are present in equal proportions in a solution in a state of equilibrium, and upon crystallisation one or other of these assumes the solid form. Taking those cases where a substance has a constitution which it is believed has been correctly ascertained by chemical reactions, and which yields two isomeric alkyl derivatives, it becomes a question as to which of these the parent substance has directly given birth to. The evidence from chemical reactions has in many cases failed to give a satisfactory answer, but the curves of molecular vibrations of such substances afford the desired information concerning the relationship of their constitution to that of their respective derivatives.

Most convincing evidence has been afforded by observations on their spectra, that several of the parent substances are really not what they seem to be.

Thus, isatin and methyl pseudo-isatin yield curves which are almost identical, the sole difference between them being due to the substitution of the alkyl radical for hydrogen, the nature of which difference might have been predicted.

Clearly the parent substance and the pseudo-derivative are of the same nature and constitution.

Carbostyril and methyl-pseudo-carbostyril, *o*-oxycarbanil and its ethyl ether, obtained by boiling with potash and ethyl iodide, are also similarly related, and they possess the ketonic or lactam structure.

On the other hand methylisatin, carbostyril, and the other ether of *o*-oxycarbanil yield curves which are essentially different from the foregoing, and are enolic or of the lactim type. Generally speaking, the ketonic are more stable than the enolic forms. Dibenzoyl-methane is ketonic, and the tautomeric substance oxybenzal-acetophenone is enolic, and in this instance the enolic form is that with the greatest stability. The two substances yield different curves, and the gradual change of the less stable into the more stable form can be traced by photographing the spectra of the solutions at intervals.

The ethyl esters of dibenzoyl succinic acid are of interest in this connection. There are three isomers known out of the thirteen which are possible, and the spectra of these have been studied. Knorr has given three formulæ for what he designates the α, β, and γ esters. Of these there are two, the β and γ forms, which give identical absorption curves: they are of the ketonic type, and structurally identical, but configuratively different, being stereo-isomerides.

The curve of molecular vibrations of the α ester is quite different from that common to the β and γ compounds. The α compound is of the enolic type, and it changes spontaneously at ordinary temperatures into the ketonic, thus showing that in this case also the latter is the more stable. The transition from the one

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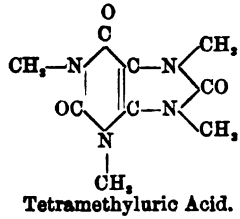
form to the other was seen to be in progress, and after an interval of only three hours the absorption band of the enolic ester had almost entirely disappeared. In three weeks the transformation had become complete, as was shown by the molecular vibration curve of the α ester being almost exactly coincident with that of the β and γ forms.

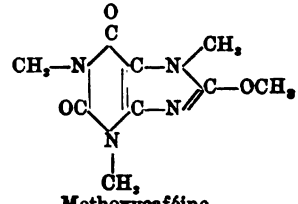
Another interesting example is afforded by the study of phloroglucinol, it being a substance with a constitution of a somewhat doubtful character, for owing to the ambiguity of its behaviour towards chemical reagents it is impossible to arrive at a decision from chemical evidence whether the oxygen atoms are present in enolic or ketonic groups. Towards some substances it behaves as a phenol, towards others as a ketone. The doubt also presented itself as to whether phloroglucinol from various sources had the same constitution, and, further, whether there might not be two isomeric forms of the compound present in equal proportions in a solution of the substance. Specimens of phloroglucinol prepared in five different ways from different materials gave curves of molecular vibrations which were identical: this decided the question absolutely; they are one and the same substance. If the constitution of the substance is that of a trihydroxybenzene or phenol, then the trimethyl ether should exhibit an absorption curve differing but slightly in detail from that of the parent substance; and, furthermore, the latter should exhibit a general resemblance to the curves of pyrogallol and phenol. This was found actually to be the case in both particulars.

Finally, with regard to tautomerism, it may be considered as decided that no evidence has been obtained based upon either physical measurements or chemical reactions of, first, the presence of a 'wandering' atom of hydrogen as a characteristic of compounds which exhibit tautomerism; secondly, that solutions of tautomeric compounds do not contain equal quantities of the two substances, or enolic and ketonic forms in equilibrium, and that if both are present one so greatly preponderates over the other that no trace of any but the one compound can be detected; thirdly, it has been observed that some substances do change spontaneously from one form to another, and that this change sets in very quickly after the substance has been dissolved; fourthly, that substances change from one form to another under the influence of different reagents, as, for instance, cotarnine, as Dobbie and Lauder (1903) have shown, in presence of methyl alcohol or of caustic soda, and again in presence of potassium cyanide. In fact it appears that under the influence of different reagents one or other of the two compounds is the more stable, and the more stable substance is then formed.

A reaction is recorded in the researches of Emil Fischer where it appears that two tautomeric forms are produced simultaneously from oxycaféine. When the silver salt of this substance is heated with methyl iodide it yields a mixture of tetramethyl uric acid and methoxycaféine, the characteristic groupings in which are $-NH-CO-$ and $-N=COH-$, the hydrogens being methylated. This is a singular reaction which has not yet been studied spectrographically.



Tetramethyluric Acid.



Methoxycaféine.

The Absorption Spectra of Alkaloids.

The interest attached to an examination of the absorption spectra of the alkaloids is not alone the fact that a means of recognising, detecting, and estimating such substances was devised, but still more that we may learn something of their chemical constitution. Many of the poisonous alkaloids give no distinctive chemical reactions, and in certain cases the means of recognising them are

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restricted to observations on their crystalline form and their physiological action. The physiological action of certain alkaloids of an extremely deadly character is remarkable enough to prove a means of their identification when the effect on the human subject is under observation. The first experimental work on the absorption spectra of the alkaloids arose out of a celebrated trial for murder, which engaged much attention in the year 1882. It was proved that the lethal drug administered was aconitine.

To identify this substance, of which there are several varieties, it was necessary at that time to resort to physiological tests made upon small animals.

Such a course always affords an opportunity for forensic arguments based upon the evidence adduced. To substitute absolute physical measurements for physiological tests seemed to present facilities for securing justice by removing any doubt of the identity of an unknown substance with the nature of one which is known. Alkaloids yield spectra of two kinds, those which do not and those which do exhibit absorption bands, the difference between the two classes of substances being one dependent on the constitution of the nucleus or ultimate radical of the compound. It is possible not only to identify substances, but also to determine the quantity present in a mixture or solution, and this has actually been done.

Alkaloids which are derived from benzenoid hydrocarbons, pyridine, quinoline, or phenanthrene give evidence of their origin by their spectra. It is therefore advantageous to make a careful study of the absorption spectra of the substances themselves and of the various products derived from them when studying their constitution. It was remarked while the work was in progress that the quinine spectrum curve was probably due to the conjugation of four pyridine or two quinoline nuclei. It is known now to be a substance of a complicated structure containing one quinoline nucleus. It differs from cinchonine only by one methoxyl group in the *para*-position. Observations made on simple bases differ from those made on substitution products, such as alkyl derivatives, in this respect, that the bases are the more diactinic, while addition products, such as hydrogenised compounds, and also salts of the alkaloids such as hydrochlorides, are more diactinic than the simple bases. It was shown by the researches of Alder Wright that different preparations of aconitine can yield substances slightly differing in constitution. On examining them it was shown that these preparations yielded different absorption curves the variations in which were due to differences in the constitution of the different preparations. To state a particular case of a well-defined character, the aconitine from *aconitum napellus* and japaconitine from a Japanese aconite prepared by Alder Wright had practically the same absorption spectrum and yielded similar curves; but that of japaconitine was just what might be expected from a substance with a nucleus of a similar constitution, but about twice the molecular weight of aconitine; in other words, a condensation of two molecules of aconitine into one—namely, what was observed in the spectra of morphine and apomorphine, a much greater absorptive power with a similar absorption curve.

It was shown that japaconitine has a constitution modified in such a manner; it being, in fact, what was termed by Alder Wright a sesquiapoaconitine; and the formulæ given for these substances are respectively: Aconitine, $C_{34}H_{47}NO_{11}$; japaconitine, $C_{66}H_{88}N_2O_{21}$, which is in agreement with the spectrum observations. It has, however, been supposed by Freund and Beck that the two substances are identical.

Strychnine and brucine are two alkaloids evidently closely related, but little is known about their constitution: both seem to contain a pyridine nucleus united to what is probably a pyrrolic nucleus, the two constituting a conjugated nucleus resembling that of quinoline. The difference between brucine and strychnine is said to be simply that the former contains two methoxyls. The absorption curves show a wider difference than this, and it was predicted that strychnine appears to be a derivative of pyridine, but brucine is more probably a derivative of tetrahydroquinoline, or an addition product. of quinoline of the same character, since there is a remarkable similarity between the curves of the two substances.

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I would suggest that for the future evidence from their spectra be taken into account in studying their constitution.

Stereo-isomerism in the Alkaloids.

Many alkaloids having the same formula are stereo-isomerides, and those related in this manner exhibit molecular absorption curves which are identical. The following examples are quoted by Dobbie and Lauder (1903) as the result of their investigations: dextro-corydaline and inactive corydaline; narcotine and gnoscopine; tetrahydroberberine and canadine. Where two compounds are known to have the same formula, and one of these is optically active, the other inactive, it may be inferred, as Dobbie and Lauder have pointed out, that they are not optical isomerides if their absorption curves are different; thus canadine and papaverine have the same formula, but their absorption curves show that they are structurally different.

It is a general rule that substances which agree closely in structure exhibit similar series of absorption spectra, while those which differ essentially in structure show absorption curves which are different; and to this rule neither aromatic compounds, alkaloids, nor dyes and coloured substances form any exceptions. That this is so is easily understood from the theory of absorption spectra. It must, however, be distinctly understood that the essential feature of importance in all such investigations is the quantitative relation of the substance to its spectra, whether these relations are based upon equal weights of material or equimolecular proportions in solutions of given volume and thickness.

The relationship of morphine, $C_{17}H_{17}NO(OH)_2$, and codeine, or methylmorphine, $C_{17}H_{17}NO.(OH)(OCH_3)$, was shown by their spectra, the latter being a homologue of the former. A similar instance has been investigated recently by Dobbie and Lauder. The resemblance between the spectra of laudanine, $C_{20}H_{25}O_4N$, and laudanosine, $C_{21}H_{27}O_4N$, confirms the view that they are homologous bases. The close agreement of their absorption curves with those of corydaline and tetrahydropapaverine clearly indicates a similarity in structure to that of these alkaloids, but the relationship of laudanosine to corydaline is probably closer than to tetrahydropapaverine, and may be best explained by the formulæ

$$\underset{\text{Corydaline.}}{C_{22}H_{27}O_4N} - CH_2 + H_2 \quad \backsimeq \quad \underset{\text{Laudanosine.}}{C_{21}H_{27}O_4N}$$

The removal of a methyl group from such a compound would scarcely cause any appreciable change in the curve of molecular vibrations, and very many cases are known where, when two atoms of hydrogen are introduced into a compound without altering the close linking of the carbon atoms of the ring formation in the compound, the alteration in the spectrum is insignificant.

A particularly interesting example of tautomerism already mentioned has been observed by Dobbie and Lauder in studying the constitution of cotarnine, a substance prepared from narcotine. Three formulæ have been proposed for it: one represents it as an aromatic aldehyde in which one hydrogen is replaced by an open change containing nitrogen; a second gives it the character of a carbinol base; while a third that of an ammonium base. It has been supposed that in solution it is a mixture of two or all three such substances in a state of equilibrium, but as to what is the formula to be assigned to solid cotarnine the data are insufficient to determine. There are, however, two different solutions of the substance obtainable; that in ether or chloroform is quite colourless, like the solid; but a solution in water or alcohol is yellow. From the molecular absorption spectra of these solutions and of certain derivatives with which they are compared there is very distinct evidence that a solution in alcohol or water contains the ammonium base, while under the influence of sodium hydroxide it assumes the condition of the carbinol form. Moreover, the rate of transformation and the conditions which influence this isomeric change have been studied.

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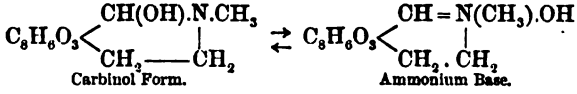
It suffices here to state that a solution containing entirely the one form may be converted wholly into the other.

The two formulæ referred to are given below :—



Emission Spectra.

Spark Spectra and their Constitution.

As it became necessary to make accurate measurements of absorption spectra in the ultra-violet, the work of obtaining the wave-lengths of lines in twenty metallic spectra was undertaken. They were for the most part in a region which, except in the case of two or three elements, had not been previously explored. A small Rutherford grating was employed, combined with quartz lenses with a focal length of three feet. Experience had shown that it was advisable in describing these spectra to give measurements in hundredths of an inch of the positions of the lines on the published photographs of the prismatic spectra in the 'Journal of the Chemical Society' (March 1882), and to follow Lecocq de Boisbaudran by giving a description of the character of each of the lines. In this way they are easily identified, and the value of the measurements for practical purposes is greatly enhanced. Prior to the publication of the work (1882), in the prosecution of which Dr. Adeney was associated with me, Liveing and Dewar, who had been engaged on a similar investigation, but operating in a different manner, published an account of the spectra of the metals of the alkalies and alkaline earths, and subsequently the lines of iron, nickel, and cobalt. They showed a rhythmic grouping of the lines to be characteristic of the spectra of the alkali metals.

In connection with the prismatic spectra which were photographed some remarkable facts were noticed; for instance, the character of the lines belonging to different groups of elements was a noticeable feature, as well also their disposition or arrangement, more particularly in the ultra-violet. Similarities in the visible spectra of zinc and cadmium, of calcium, strontium, and barium, and in those of the alkali metals had been observed by Mitscherlich, by Lecocq de Boisbaudran, and also by Ciamician. As to the grouping of the lines as observed on the photographs, it appeared that the spectra of well-defined groups of elements had characteristics in common which were different from those of other groups. For instance, the alkali metals differed from the alkali earth metals which appeared to form a group by themselves. Then in marked contrast to these simple spectra were those of iron, nickel, and cobalt, which though very complicated were seen to be much alike. Nearest to these but differing from them in certain respects were the palladium, gold, and platinum spectra.

It was observed how these elements with certain chemical and physical properties in common could be recognised as being relations owing to their family likeness when their spectra were photographed. Then it was remarked that the spectra of magnesium, zinc, and cadmium, had distinctive characters in common; for instance, the individual lines in these spectra were marked by similar characteristics, such as a great extension of the strong lines above and below the points of the electrodes. This extension was increased with the atomic mass of the metal, and with the greater atomic mass in this group the volatility of the metal is also greater. An arrangement of the lines in pairs and triplets was noticed, the triplets being repeated, but less distinctly than in the first instance, and again repeated sharply but less strongly, so that there were three different sets of triplets in each spectrum. The point of greatest interest and importance was the connection traced between the atomic mass and the numerical differences observed in the intervals between the lines of different groups when measured by their oscillation frequencies.

These differences were not in the spectrum of one element, but were in the lines

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of each metal of the group, and were clearly associated with the atomic mass and chemical properties in each case.

The arrangement of the lines, which was common to all the metals in the magnesium, zinc, cadmium group, may shortly be described as follows:—Three isolated lines and one pair of lines in magnesium, with four sets of triplets; one isolated line and one pair of lines in zinc, with three sets of triplets; one isolated line and one pair of lines in cadmium, with three sets of triplets.

Besides the arrangement of these lines there were in the spectrum of each element two groups of the most refrangible lines, consisting one of a quadruple group and the other of a quintuple group, the groups and the lines composing them being similarly disposed in each spectrum. It was, however, not distinctly proved that these particular groups were strictly homologous, the most refrangible lines in the zinc spectrum being very difficult to photograph even on specially prepared plates, though the lines are strong. It was furthermore observed that with an increase in the atomic mass the distances between the lines both in pairs and triplets were greater. The same was the case with the quadruple and quintuple groups. In the magnesium spectrum, if we compare the first with the second group of triplets, we find the intervals extending from the first line in the first group to the first line in the second group, and from the second line in the first group to the second line in the second group, and from the third line in the first group to the third line in the second group, when measured in terms of oscillation frequencies to be 677·1, 677·0, and 677·4. Similarly taking the second and third groups it is 391·2, 391·1, and 391·1. Between the third and fourth groups in like manner it is 230·9, 233, and 233; so that the intervals diminish with increase of refrangibility of the lines.

In the zinc spectrum the intervals between the lines in the first and second groups are 910, 910, and 910; in the second and third groups 582, 581, and 583.

In the cadmium spectrum the corresponding intervals are 801·5, 800, and 800; in the second and third groups 588, 589, and 587. The more accurately the lines are measured the more exactly do these differences correspond. It is scarcely necessary to point out that the differences in the atomic masses of the elements are in round numbers where H = I, Mg 24, Zn 65, and Cd 112.

The *Law of Constant Differences* rendered it evident that the spectra of the elements were subject to a law of homology, which was closely connected with the atomic mass and with their chemical and physical properties.

It was, in fact, found, in accordance with the periodic law, that the spectra of definite groups were spectra similarly constituted, from which it was deduced that they are produced by similarly constituted molecules. It is evident that there is periodicity in their spectra. The metals studied being all monatomic in their molecular condition, the conclusion was inevitable that the atoms were of complex constitution, and that not only was the complex nature of these atoms disclosed, but it was also shown that groups of elements with similar chemical and physical properties, the atomic weights of which differed by fixed definite values, were composed of the same kind of matter, but the matter of the different elements was in different states of condensation, as we know it to be in different members of the same homologous series of organic compounds. If this were not the case, the mass or quantity of matter in the atom would not affect in the same manner its rate of vibration—which the facts observed lead us to conclude that it does—and the chemical properties of the substances would differ more widely from one another, and the differences between them would not be gradational, which in fact they are. It was thus impossible to believe that the atoms were the ultimate particles of matter, though so far as chemical investigations had proceeded they were parts which had not been divided. Here the conviction was forced upon one that matter might exist in a state which had hitherto been unrecognised by those who accepted the atomic theory without searching beneath it. All that the atomic theory enabled the chemist to take account of were the laws of combination and decomposition of the forms of matter that are ponderable and of sufficient mass to be weighable on the finest balances, which after all are but crude and imperfect instruments for the study of matter, since they are capable only of determining

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differences between masses of tangible size. It became conceivable that matter in the state of gas or vapour might become so attenuated that repulsion of the molecules would be greater than the attraction; that they would then no longer form aggregates, and in consequence would cease to be weighable. In such a condition they may be imagined to constitute the ether, and in view of this conception there may be recognised four physical conditions of material substances, namely, solid, liquid, gas, and ether.

It is more than twenty years ago since the study of homology in spectra led me to the conviction that the chemical atoms are not the ultimate particles of matter, and that they have a complex constitution.

That the atoms of definite groups of chemically related elements are composed of the same kind of matter in different states of condensation is not a dream or a view of a visionary character, for it is based upon definite observations controlled by exact physical measurements, and is therefore in the nature of a theory rather than an hypothesis. Batchinski (1903) regards the atoms as being in a state of vibration, and the periods of vibration of related elements appear to stand in a simple relation to their properties. The mass of an atom is proportional to the square of its period of vibration, and conversely the vibration period of the atom may be calculated from the square root of the atomic weight. These values have been calculated and arranged according to Mendeléef's classification, whereby it is shown that there is a decided tendency to form harmonic series in the vertical columns. The deviations are probably capable of explanation, as the author believes, on the ground that the atom is not to be regarded as a material point, but as a material system. It is well to remember that the precursor of the Periodic Law was Newland's Law of Octaves.

I have always experienced great difficulty in accepting the view that because the spectrum of an element contained a line or lines in it which were coincident with a line or lines in another element it was evidence of the dissociation of the elements into simpler forms of matter. In my opinion, evidence of the compound nature of the elements has never been obtained from the coincidence of a line or lines exclusively belonging to the spectrum of one element with a line or lines in the spectrum exclusively belonging to another element. This view is based upon the following grounds:—First, because the coincidences have generally been shown to be only apparent, and have never been proved to be real; secondly, because the great difficulty of obtaining one kind of matter entirely free from every other kind of matter is so great that where coincident lines occur in the spectra of what have been believed to be elementary substances they have been shown from time to time to be caused by traces of foreign matter, such as by chemists are commonly termed impurities; thirdly, no instance has ever been recorded of any homologous group of lines belonging to one element occurring in the spectrum of another, except and alone where the one has been shown to constitute an impurity in the other; as, for instance, where the triplet of zinc is found in cadmium and the triplet of cadmium in zinc; the three strongest lines in the quintuple group of magnesium in graphite, and so on. The latest elucidation of the cause of coincidences of this kind arises out of a tabulated record from the wave-length measurements of about three thousand lines in the spectra of sixteen elements made by Adeney and myself. The instances where lines appeared to coincide were extremely rare; but there was one remarkable case of a group of lines in the spectrum of copper which appeared to be common to tellurium; also lines in indium, tin, antimony, and bismuth which seemed to have an origin in common with those of tellurium.

It is difficult to separate tellurium from copper, and copper from tellurium, by ordinary chemical processes. Dr. Köthner, of Charlottenburg, has succeeded in obtaining very pure tellurium from the spectrum of which these lines and also several others have been almost entirely eliminated, which shows that they are foreign to the element, and that his specimen of tellurium is probably purer than any previously obtained. For determining the atomic weight of tellurium it is of course necessary to obtain it in the greatest possible state of purity; and it may be mentioned that the material which Staudenmaier employed for this purpose was found, from Köthner's photograph of its spectrum, to be a very pure specimen.

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The prosecution of researches in connection with the constitution of spectra was initiated by Johnstone Stoney, by Balmer with respect to hydrogen, and continued by Rydberg, Deslandres, Ames, and, above all, by Kayser and Runge, who by an elaborate and exhaustive investigation of the arc spectra of the elements have given us formulæ by which the wave-lengths of lines in the spectra of different elements in certain definite groups may be calculated from their atomic masses. They also showed the spectra to be constituted of three series of lines, the principal series and two subordinate series, one sharp and the other diffuse. Lately, Ramage has given us a simpler formula, which applies to several groups, and he has co-ordinated the spectra of several of the elements with the squares of their atomic masses, and also their atomic masses with others of their physical properties.

It may here be remarked that the homology of the spark spectra in the magnesium, zinc, and cadmium series was at first called in question by Ames, though he proved the arc spectra of zinc and cadmium to be strictly homologous.

Preston decided the question by demonstrating by means of beautiful photographs that corresponding lines such as the pairs, triplets, and the quadruple groups in the spark spectra of the three metals when under the influence of a very powerful magnetic field underwent the same kind of change; for instance, each quadruple group changed to sextuple, the second and fourth lines in each group becoming double. Lines in spectra which have not the same constitution behave differently. Recently Runge and Paschen have arrived at the same conclusion; and, furthermore, have established homology in the spectra of sodium, copper, and silver; also between aluminium and thallium. Indium is almost certainly homologous with aluminium and thallium, but it was probably not investigated on account of its rarity. Marshall Watts has pointed out that a relationship exists between the lines in the spectra of some elements and the squares of their atomic weights, from which it is possible to calculate the atomic weight of an element if that of another in the same homologous series is known, and the oscillation frequencies of corresponding lines are known. This enables the determination of atomic weights to be controlled with quite as much efficiency and certainty in many instances as by specific heat or vapour-density determinations of the metals.

The first application of the observed homology in spectra was directed towards the question of the atomic mass of beryllium, for which purpose the lines in the ultra-violet spark spectrum of this element were first photographed and measured. The nature of the evidence on the subject adduced at the time was in outline as follows:—

'If, as Nilson and Petterson suggest, the position of beryllium is at the head of a series of triad rare earth metals, the element scandium (at. wt. 44) and yttrium (at. wt. 89) must be members of the same group. If this be the case the spectra of the three elements must have certain characters in common, for the series of which aluminium and indium are the first and third terms yield strictly homologous spectra. As a matter of fact no two spectra could be more dissimilar than those of beryllium and scandium.'

Having compared the photographs and wave-length measurements of a large number of spectra of the elements, I felt justified in making the following remarks:—

'The spectrum of beryllium exhibits no marked analogy with the calcium, the magnesium, or the aluminium spectra, all of which are members of well-defined homologous series. There is nothing similar in it to the boron, silicon, or carbon spectra, nor to those of the scandium, yttrium, or cerium. The spectrum of lithium is most closely analogous to that of beryllium in the number, relative positions, and intensities of the lines. This leads to the conclusion that beryllium is the first member of a dyad series of metals, to which in all probability calcium, strontium, and barium, as a sub-group, are homologous, its atomic mass being 9·2, its place is above magnesium.'

Subsequently Nilson, and also Humpidge, by chemical evidence and from vapour-density determinations of certain compounds, substantiated the conclusion

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previously arrived at by Emerson Reynolds, that the atomic mass of beryllium was not 13·8 but 9·2.

The next practical application of the spark spectra was to the analysis of rhabdophane, a mineral found many years ago in Cornwall and described by Heuland in 1837 as a zinc blende of a peculiar character.

This mineral I found to contain neither zinc nor sulphur, and therefore it is not a blende. It is, in fact, a phosphate of the formula $R_2O_3.P_2O_5.2H_2O$, in which the oxides of cerium, didymium, lanthanum, and yttrium may wholly or in part replace each other. The didymium absorption spectrum is well seen both by reflection from the surface and transmission through thin sections of the mineral. The spark spectrum of the yttrium chloride obtained from rhabdophane was compared with that observed by Thalén and ascribed to yttrium. Of the fifty-one lines in the spectrum of yttrium thirty-eight were absent from the yttrium obtained from rhabdophane, and it was concluded that the purest yttrium was that which yielded the simplest spectrum. This was the first occasion of the finding of yttrium in any British mineral. Quite recently a confirmation of this view has been obtained by comparing this spectrum with lists of the arc lines of yttrium and ytterbium which have just been published by Kayser (1903).

Penfield analysed a mineral found in the United States which he named scovellite: it proved to be identical in species with rhabdophane.

Flame Spectra at High Temperatures.

What are commonly known in the chemical laboratory as flame spectra are chiefly those of the metals of the alkalies and alkaline earths; also of gallium, indium, and thallium. The researches of Mitscherlich and Lecocq de Boisbaudran first showed that copper, manganese, and gold gave flame spectra. Lockyer, Gouy, and Marshall Watts also investigated flame spectra.

In 1887 I used iridium wires one millimetre thick, twisted into loops upon which fragments of minerals were heated in the oxygen blowpipe flame. Natural silicates yielded spectra not only of alkalies but of the alkaline earths, and also distinct manganese spectra. Baryta, strontia, and lime gave spectra when insoluble compounds such as the sulphates were thus examined at high temperatures. Iron, cobalt, and nickel gave spectra even when compounds such as the oxides were heated strongly. But iridium, though infusible, is somewhat volatile, and contributes a line spectrum to the flame. In 1890 thin slips of the mineral kyanite and even pieces of tobacco pipe were used instead. Experience with this method of working went to show how the flame spectra of oxides of calcium, strontium, and barium could be separated from those of lithium, sodium, potassium, rubidium, and cæsium, as observed in the Bunsen flame. Furthermore, that even the most volatile of these substances could be made to yield a continuous coloration from a single bead of salt for a period exceeding fifteen minutes, and extending to one or two hours, so that measurements of the lines might be made with some degree of certainty.

In order to study the flames emitted from furnaces during metallurgical operations, and particularly from the mouth of Bessemer vessels, it became necessary to ascertain what really were the lines of the elements observed under different conditions at a high temperature, and accordingly systematic methods of study were developed from the previous somewhat tentative experiments.

In all the flame spectra obtained by the oxyhydrogen blowpipe the ultra-violet line spectrum emitted by water vapour which had been discovered by Huggins and by Liveing and Dewar was visible on the photographs by reason of the combustion of the hydrogen in the hydrocarbon, or the hydrogen gas itself, when burnt along with oxygen. The flame spectra are always shorter than those obtained from the arc or from condensed sparks. After an extended examination of spectra produced by the oxyhydrogen blowpipe from solid substances, the knowledge obtained was applied to the examination of the flames coming from the Bessemer vessel during the 'blow' during all periods from the commencement to the termination. These observations were made at the London and North-Western Railway Steel Works at Crewe; and at Dowlais, in South Wales. In

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collaboration with Mr. Ramage, a large number of these complicated spectra were photographed at the North-Eastern Steel Works, where the Thomas-Gilchrist process is carried out. The spectra were fully described and measured, with the result that every one of the lines and bands was accounted for. A new line belonging to potassium was discovered to have peculiar properties. Gallium was proved to be present in the Cleveland ore from Yorkshire, in the finished metal, in clays and in all aluminous minerals, even in corundum. Also, by very accurate determinations of the wave-lengths of its principal lines, gallium was proved to be a constituent of the sun. Moreover it was found in several meteorites. Pure gallium oxide was separated, by analytical methods, from iron ores and other materials; and the proportion of the metal in the steel rails made by the North-Eastern Steel Company, of Middlesbrough, was determined and found to be one part in thirty thousand. This Yorkshire steel is richer in gallium than any other substance from which it has been extracted; for instance, the Bensburg blende, supposed hitherto to be the richest ore, contains only one part in fifty thousand.

By observations on the spectra, the thermo-chemistry of the Bessemer process of steel manufacture was studied, and the temperatures attained under varying conditions were estimated. The demonstration of the great volatility of most metals, and of many metallic oxides in an undecomposed condition, at the temperature of the oxyhydrogen blowpipe and of the Bessemer flame was of special interest. The metals chiefly referred to are copper, silver, lead, tin, manganese, chromium, iron, cobalt, nickel, palladium, gold, and iridium. Several of these, such as silver and gold, have lately been distilled *in vacuo* by Krafft.

Banded Flame Spectra.

Well-defined groups of elements yield banded flame spectra which have a similar constitution; thus magnesium, zinc, and cadmium yield bands composed of fine lines, degraded towards the violet, while fluted band spectra of beryllium, aluminium, and indium were found to be degraded towards the red. Thallium also yields a fluted spectrum; gallium gives a line spectrum; lanthanum gives bands degraded towards the red; palladium gives bands in the nature of flutings composed of fine lines; germanium gave very faint indications of bands; rhodium and iridium both lines and bands. It became manifest that elements belonging to the same group in the periodic system of classification exhibited banded spectra which are similarly constituted, and hence similarly constituted molecules of the elements have similar modes of vibration, whether at the lower temperature of the flame or at the higher temperature of the arc or spark. Banded spectra are thus shown to be connected with the periodic law.

A great advantage is to be derived from an investigation of banded spectra from a theoretical point of view, as well as from the application of this method to the analysis of terrestrial matter. While the spectra are easily obtained, they can be applied in a very simple manner to the chemical analysis of minute quantities of material, and may readily be made quantitative.

M. Armand de Gramont has described a method of obtaining spectra of metals and metalloids by means of a spark, and has given the analysis of eighty-six mineral species. The novelty and importance of his work lies in the method of obtaining spectra of such constituent substances as chlorine, bromine and iodine, sulphur, selenium and tellurium; also phosphorus and carbon when in a state of combination, as sulphates, phosphates, carbonates, &c.

There is a possibility of utilising this method for the quantitative determination of carbon, sulphur, and phosphorus in iron and steel during the process of manufacture.

Definition of an Element.

In a discussion on the question of the elementary character of argon in 1895 it was pointed out by me that argon gave a distinct spark spectrum by the action of condensed sparks, and therefore, on this evidence alone, it must be regarded as an element. The fact that it gave two spectra under different conditions was not

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opposed to, nor did it invalidate, this evidence, because such an element as nitrogen not only emits two spark spectra, but the two spectra can be readily photographed simultaneously from the same spark discharge.

It was proposed by M. de Gramont at the International Congress in Paris in 1900, and agreed, that no new substance should be described as an element until its spark spectrum had been measured and shown to be different from that of every other known form of matter.

This appears to me to have been one of the most important transactions of the Congress. The first application of this rule has resulted in the recognition of radium as a new element: it is characterised by a special spark spectrum of fifteen lines which have been fully studied and measured by Demarçay. It shows no lines of any other element.

Another application of this rule has recently been made by Exner and Haschek with preparations of the oxide of an element obtained by Demarçay, and named europium. It exhibits 1193 spark lines and 257 arc lines.

I have already mentioned that one feature strikingly shown in the spectra of chemically related elements was the wider separation of the lines in pairs, triplets, or other groups; and that this was in some way related to the atomic mass, since the separation was greater in those elements whose atomic weights were greater. Kayser and Runge, and also Rydberg, have shown that in the series of alkali metals the atomic weights are very nearly proportional to the squares of the differences between the oscillation frequencies of the lines, that is to say, the squares of the intervals between the lines. Runge and Precht have recently shown that in every group of elements that are chemically related the atomic weight is proportional to some power of the distance separating the two lines of the pairs of which the spectrum is constituted. In other words, if the logarithms of the atomic weight and distance between the lines be taken as coordinates the corresponding points of a group of elements which are chemically related will lie on a straight line. Applying this law to the determination of the atomic weight of radium they find that the strongest lines of the new element are exactly analogous to the strongest barium lines, and to those of the closely related elements magnesium, calcium, and strontium. The intervals between the two lines of each pair in the principal series, and in the first and second subordinate series, if measured on the scale of oscillation frequencies, are equal for each element, and the same law holds good for the spectrum of radium. From this the value 257·8 was found for the atomic mass of the element. This does not quite accord with the number obtained by Madame Curie, who found it to be 225. It will be interesting to see which number will eventually be proved to be the more correct.

It is now many years since I first pointed out that the absolute wave-lengths of the lines of emission spectra of the elements are physical constants of quite as great importance in theoretical chemistry as the atomic weights; in the light of recent discoveries this statement may be said to be now fully justified.

Radio-active Elements.

From the study of rays of measurable wave-lengths we have lately sailed under the guidance of M. Henri Becquerel into another region where it is doubtful whether the rays conform to the undulatory theory. In fact the rays are believed to be charged particles of matter, charged, that is to say, with electricity. Beyond doubt they are possessed of very extraordinary properties, inasmuch as they are able to penetrate the clothing, celluloid, gutta percha, glass, and various metals. They are, moreover, endowed with a no less remarkable physiological action, producing blisters and ulcerations in the flesh which are difficult to heal. It is an established fact that such effects have been caused by only a few centigrams of a radium compound contained in a glass tube enclosed in a thin metallic box carried in the pocket.

From this we can quite understand that there is no exaggeration in the statement attributed to the discoverer, Professor Curie, by Mr. W. J. Hanmer, of the American Institute of Electrical Engineers, that he would not care to trust

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himself in a room with a kilogram of pure radium, because it would doubtless destroy his eyesight, burn all the skin off his body, and probably kill him.

It remains for me to express regret that without an undue extension of the time devoted to this Address it would have been scarcely possible to afford adequate treatment to the absorption spectra of inorganic compounds, particularly those of the rare earths, and such also as afford evidence of the chemical constitution of saline solutions; or of organic compounds closely related to coloured substances and dyes, the investigation of which leads to the elucidation of the origin of colour, and serves to indicate the nature of the chemical reactions by which coloured substances may be evolved from those which are colourless.

Chemistry is popularly known as a science of far-reaching importance to specific arts, industries, and manufactures; but it occupies a peculiar position in this respect, that it is at one and the same time an abstract science, and one with an ever-increasing number of practical applications. To draw a line between the two and say where the one ends and the other begins is impossible, because the theoretical problem of to-day may reappear upon the morrow as the foundation of a valuable invention.

The following Papers and Reports were read:—

1. *Apparatus for Determining Latent Heat of Evaporation.* By Professor J. Campbell Brown, *D.Sc.*

The apparatus exhibited furnishes a direct method of determining the latent heat of evaporation, at the boiling point, of any volatile substance of which something approaching 50 grammes can be obtained. None of the substance is lost, and no comparison with any other substances is required. The amount evaporated is accurately weighed and the amount of heat employed in evaporating it is accurately measured.

From 15 to 20 grammes of the substance are placed in a tube about 10 cm. long and 23 mm. wide, which is closed at one end and drawn out at the other end to an orifice 1·5 mm. wide. The tube contains in its lower third a spiral of fine platinum wire welded at its extremities to thick platinum wire terminals. These terminals pass through the bottom of the tube and dip into mercury contained in U-shaped projections from the expanded neck of a flask of 30 to 50 c.c. capacity. This tube is heated to the boiling point of the liquid in the manner about to be indicated and is then closed temporarily by a cap and carefully weighed. It is then replaced in the flask. A glass cap is ground on to the neck of the flask, and is provided with an orifice through which vapour can escape into an outer jacket. The space between the tube and the cap and neck of the flask forms the inner jacket. A long glass cap having an escape tube for the condensed liquid is fixed over the whole expanded neck of the flask by means of a ring of cork or indiarubber.

A convenient quantity of the liquid is placed in the flask and boiled by a suitable bath. Its vapour passes into the jacket above and raises the temperature of the tube and its contents to the boiling point of the liquid. When the weighed tube and its contents have been replaced and the temperature is constant, a current of electricity is passed through the spiral by means of the mercury in the U-tubes. The time is noted and an ammeter in the circuit is watched and recorded every two minutes. A voltmeter is also switched into the circuit every two minutes and read. At the end of, say, twenty minutes, the average ampères and volts are recorded. From these data the heat expended in evaporation is calculated. The tube is taken out and re-weighed to ascertain the weight of substance evaporated by this quantity of heat. The double jacket of its own vapour keeps the temperature constant at the boiling-point and prevents loss of heat into the room.

The ammeter and voltmeter should be accurate to at least $\frac{1}{100}$ of the total reading employed; and must therefore be more accurately calibrated than are the best instruments usually supplied by the trade.

The first experiments should be rejected. With practice the results are accurate and the method easy. The variations in different experiments by different operators are usually a small decimal figure.

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As an example the results with benzene are given. $\frac{ML}{T}$ is Trouton's formula; θ is the critical temperature.

Latent Heat of Benzene.

Time	Current	Amp.	E.M.F. (volts)	Correct weight of substance evaporated (grms.)	Latent heat	Mean	$\frac{ML}{T}$	$\frac{ML}{\theta}$
10 min.	3 cells	0·885	5·15	6·904	95·08			
10 min.	4 cells	1·174	6·92	12·341	94·82			
10 min.	4 cells with 1 ohm resistance	1·014	5·93	9·124	94·91	94·93*	20·92	13·10

* 94·4 Griffith and Marshall; 93·45 Schiff.

2. *On some Derivatives of Fluorene.* *By* Miss IDA SMEDLEY.

3. *Action of Diastase on the Starch Granules of Raw and Malted Barley.* *By* ARTHUR R. LING, *F.I.C.*

The whole of the published data referring to the hydrolysis of starch by diastase have been derived from the study of the action of the enzyme on potato-starch paste, and the application of these to practical purposes has led to misleading and erroneous conclusions. The starches of barley and other cereals differ from that of the potato in being readily attacked by a solution of diastase in the ungelatinised condition.

The author has carried out a series of mashes with barley and malt starch of various origin, the starch being mixed with the diastase preparation in the dry state and mashed with water at different temperatures for two hours.

The following table illustrates the results obtained:—

Starch employed	Mashing Temperature	[α]D 3·93	R*3·93
Barley 1899 sample	60°	140·8°	88·7
" " "	65·5	143·4	88·2
" " "	71	145·1	80·6
" 1902 sample	60	150·7	84·2
" " "	65·5	152·3	79·0
" " "	71	163·8	77·8
Kilned malt	60	150·9	84·4
" "	65·5	156·1	80·6
" "	71	161·3	67·2
Low-dried malt	60	151·6	85·3
" "	65·5	152·5	83·3
" "	71	165·7	66·6
Barley starch (paste)	65·5	168·6	52·4
Potato starch (paste)	60	154·5	81·8
" " "	65·5	155·6	71·5
" " "	71	167·1	55·3

* The symbol R denotes the percentage of apparent maltose, determined by the cupric reduction method, on the dissolved matter in solution. The symbols [α]D 3·93 and R 3·93 indicate that the total solids have been calculated from the specific gravity of the solution by the divisor 3·93.

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The very great differences between the constants yielded by the starch mashes and the starch paste conversions are apparent. It is also to be noted that the starches from different barleys give different constants, and the author hopes to continue his work in this direction. He brings forward evidence showing that in the process of mashing, as conducted in breweries, the starch granules are dissolved directly by the diastase and are not gelatinised prior to hydrolysis, as it is usually stated they are. It is probable that the products formed in these starch mashes are different from those resulting from the hydrolysis of starch paste; and it is hoped that a study of the former may yield results of both theoretical and practical importance.

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4. *Action of Malt Diastase on Potato-starch Paste.*

By ARTHUR R. LING, *F.I.C.*

Brown and Millar have shown that the so-called stable dextrin—one of the products of the hydrolysis of potato-starch paste by diastase—is converted by the further action of diastase into a mixture of about equal parts of *d*-glucose and maltose. The observation of Davis and Ling (next abstract), that no *d*-glucose is formed when unrestricted diastase acts on starch paste, stands in apparent antithesis to this. However, the author has confirmed the result of Brown and Millar, and has found further that other isolated products of diastatic action yield a proportion of *d*-glucose when submitted to the further action of unrestricted diastase; thus the maltodextrin, α of Ling and Baker, when treated in 3 per cent. solution with an active preparation of diastase at 55° for 140 hours, gave the constants $[\alpha]D$ 3·93 127 6°, R 3·93 105·6, corresponding approximately with maltose 90 per cent., *d*-glucose 10 per cent. The presence of 10·5 per cent. of *d*-glucose in the product was proved by weighing the phenylglucosazone formed under standard conditions. Taking into account the fact that potato-starch paste is never completely converted into maltose, although the final product has the constants of that sugar, and that a substance is always present which is identical with the isomaltose of C. J. Lintner, the simple dextrin of Ling and Baker, and the dextrinose of Syniewski, which when isolated and submitted to the action of diastase yields *d*-glucose, the author suggests that the reason no *d*-glucose can be detected among the products of the action of unrestricted diastase on starch paste is that that sugar is immediately condensed by the action of the enzyme forming dextrinose. When, however, diastase is preheated, its condensing action is weakened, and the *d*-glucose formed can be isolated. Attempts to condense *d*-glucose or mixtures of it with maltose have not been successful.

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5. *Action of Malt Diastase on Potato-starch Paste.*

By BERNARD F. DAVIS, *B.Sc., and* ARTHUR R. LING, *F.I.C.*

In a previous paper[1] it was shown that when malt diastase is heated in aqueous solution above the temperature at which the activity of the enzyme is at its optimum, namely 55°, the reaction with potato-starch paste at about 55° is not only slower, but different products are formed; thus *d*-glucose can be readily isolated from them after the reaction has been allowed to proceed for several hours. Special experiments, employing the same quantities of diastase which has not been heated in solution above 55°, show that *d*-glucose is not formed either from starch paste or from maltose. It therefore appears that the production of this sugar is connected with the preheating of the hydrolytic agent in solution above 55°. As a result of a very large number of new experiments, which will be published shortly, the authors have arrived at the following conclusions.

[1] *Journ. Fed. Inst. Brew.* 1902, 8, 475.

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The effect of heating a solution of diastase as above indicated is to weaken its action and also to produce an alteration in the enzyme molecule, which is moreover a permanent one, for the diastase retains its altered properties when reprecipitated from its solution by alcohol and allowed to act on starch paste at or below 55°. The alteration of the diastase is assumed by the production of *d*-glucose when it acts on starch paste, and it appears to commence when a solution of the enzyme is heated below 60°; although, judging from the small amount of *d*-glucose formed by its action, the change at the last-named temperature is not complete. As the temperature of preheating the solution is increased, the amount of *d*-glucose it is capable of producing also increases, the maximum amount being obtained by the action of diastase which has been preheated in solution at 68° to 70° for fifteen to thirty minutes. Above this temperature the destruction of the enzyme is so rapid that a much larger proportion of it has to be employed to attain the stage of the reaction at which *d*-glucose appears. Still *d*-glucose is formed by diastase which has been restricted at temperatures up to 78°, and probably above this. It has been observed in all cases that when, after the maximum amount of *d*-glucose has been formed, the solution is kept at the temperature of hydrolysis, usually 55°, the sugar just mentioned diminishes in amount, and the occurrence of this apparent condensing action of the enzyme may probably explain the failure in several cases to detect *d*-glucose among the products of hydrolysis (compare the previous abstract). The maximum amount of *d*-glucose formed in any case does not exceed about 12 per cent. of the total hydrolytic products.

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6. *The Chemical and Physical Characters of the so-called 'Mad-stone.'* By Dr. H. C. White.

It is a widespread current superstition in the Southern States of America that the sting of a *venomous* snake and the bite of a *rabid* animal (dog, &c.) may be *detected* and discriminated from an innoxious wound, and the venom of the wound *extracted*, by application of what is called the 'mad-stone.' Several of these stones came opportunely into the hands of the author, and an examination of their character was made.

The 'mad-stone' of current superstition is a very rare concretionary calculus found in the gullet of the male deer. As extracted it resembles a water-worn pebble, oblong in form, varying in size, but not greater, perhaps, than 3 inches in length by 1½ inch in thickness. A smooth flat surface is given to one side by rasping. The examination was directed to the following points:—

1. *Chemical Composition.*—Found to be chiefly tri-calcic phosphate. Exact figures of analyses given.

2. *Adherence to Cut and Torn Flesh-wounds.*—Found to vary with the mechanical character of the wound and the mode of application of the stone, without regard to venomous or non-venomous character of the wound.

3. *Absorbing Power.*—Immersed in water the stones were found to absorb to an extent of 5 per cent. of their weight. Applied to fresh wounds and carefully adjusted, blood and other fluid absorbed to a maximum extent of 2·3 per cent. the weight of the stone.

4. *Character of Matter absorbed.*—The stone after application to the wound is boiled with water, or *milk* (in accordance with the superstition). The fluid is discoloured, and is shown to be *toxic* in the case of a known venomous wound. No difference in discoloration is observable in venomous and non-venomous wounds. That the stones are not *curative* is shown by the death of animals from venomous wounds after application of the stone.

The literature of the subject has been examined. The 'mad-stone' superstition seems quite ancient. It was current in New England in Puritan times. The author has in his possession an authenticated 'mad-stone' dating from 1654. This, however, is a moderately porous *sandstone*, entirely different from the

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modern 'mad-stone' of the Southern States. It is peculiar in form, and appears somewhat as a water-worn pebble.

Specimens of the current 'mad-stone' were exhibited in illustration of the paper.

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7. *On the Reduction of Nitrates by Sewage.* *By* Professor E. A. Letts, *D.Sc., Ph.D.*, R. F. Blake, *F.I.C., and* J. S. Totton, *B.A.*

The object of this investigation was to ascertain to what extent, and with what rapidity, the nitrogenous constituents of sewage can be broken down by a suitably arranged scheme of purification, so that their nitrogen is evolved in the gaseous state. It is well known that in the most efficient systems of sewage purification by natural methods the resulting effluent is comparatively free from ammonia and organic nitrogen, but is charged with nitrates. These latter, however, do not correspond in amount with the quantities of the two former originally present, but are always less, and two of the authors have shown that during the treatment of sewage by the so-called 'contact' or 'bacteria' beds a considerable quantity of the combined nitrogen escapes as free nitrogen.[1]

The researches of Gayon and Dupetit, Tacke, Adeney, and others have shown that nitrates are themselves decomposed when in contact with sewage with evolution of nitrogen or its oxides, and carbonic anhydride.

It therefore seemed possible that by a judicious combination of the two processes, *i.e.* production and destruction of nitrates, a considerable proportion and possibly most of the combined nitrogen present in sewage might be converted into free nitrogen, and as a consequence the resulting effluent be deprived of its fertilising properties in relation to vegetation.

Such a result might appear useless, and even wasteful, under ordinary circumstances, but in the case of the sewage of Belfast, and probably in that of other towns similarly situated, it is really necessary. At Belfast, at all events, one of the authors has shown that the growth in enormous quantities of the green seaweed *Ulva latissima* and the resulting nuisance which occurs when it is washed ashore and putrefies—as happens each summer—is directly due to the fertilising properties of the sewage of the city, which is poured into the lough in an untreated condition.[2]

The experiments conducted by the authors consisted of—(I.) a study of the changes which occur when potassium nitrate is added to the effluent from a septic tank, and the speed with which they occur; (II.) an investigation as regards the cause of these changes; (III.) the action of pure cultures of specific micro-organisms in broth containing potassium nitrate.

I. *The Chemical Changes occurring when Potassium Nitrate is added to the Effluent from a Septic Tank.*

The method of experiment consisted in completely filling two similar bottles (which were then tightly stoppered), one with the septic-tank effluent alone and the other with the same effluent *plus* an accurately measured volume of a strong standard solution of potassium nitrate (1 c.c. = 10 mgs. nitric nitrogen). Allowing the two bottles so filled to remain at the temperature of the laboratory for a given interval of time, their contents were examined quantitatively as regards (*a*) dissolved gases, (*b*) nitrates, (*c*) nitrites, (*d*) free and albuminoid ammonia.

Practically all the experiments (which were eight in number) were made with

[1] 'On the Chemical and Biological Changes occurring during the Treatment of Sewage by the so-called Bacteria Beds,' by Professor Letts, D.Sc., Ph D., and R. F. Blake, F.C.S., *B.A. Rep.* 1901.

[2] This used to be the case, but works for the purification of the sewage are being pushed on rapidly, and at the present time a considerable proportion is being purified.

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mixtures of potassium nitrate and septic-tank effluent containing 2·5 parts of nitric nitrogen per 100,000 in the case of the nitrated samples. The chief general conclusions arrived at were as follows:—

(1) Potassium nitrate (and no doubt any other nitrate likely to be produced in a sewage effluent) is decomposed by the septic-tank effluent, and the nitric nitrogen is evolved, sometimes entirely as free nitrogen, sometimes partly as nitric oxide. Nitrous oxide may also be formed, but the evidence on that point is not as yet conclusive.[1] The action seems to vary with different samples of septic-tank effluent, but in four of the eight experiments the theoretical quantity of nitrogen [corresponding with the added nitrate] was found either as free nitrogen alone or along with nitric oxide.

There is no evidence from the authors' experiments to show that any considerable quantity of these gases is produced from either the free ammonia or the organic nitrogen present in the septic-tank effluent.

(2) The general character of the change is that of combustion, the oxygen of the nitrate eventually appearing either partly or entirely in the form of carbonic anhydride.

(3) In some of the experiments a little nitrite was produced, but in the majority none was found at their conclusion.

(4) The destruction of the nitrate occurs with remarkable rapidity, and in most of the experiments the whole of the added nitrate—equivalent to 2·5 parts of nitric nitrogen per 100,000 of mixture—was decomposed in twenty-four hours.

(5) In addition to the decomposition of the nitrate and evolution of carbonic anhydride the fermenting liquid experiences other changes.

There is always a *loss* of free ammonia, and as a rule a *gain* in albuminoid ammonia, but the former generally exceeds the latter. Thus in six experiments the average loss of free ammonia amounted to 0·266 part per 100,000, while the corresponding gain in albuminoid ammonia was only 0·166, or rather more than half the preceding figure.

It may also be mentioned that in two of the experiments marsh gas was found, not only in the septic tank effluent, but also in the nitrated fluid, and it is somewhat remarkable that more of the gas was found in the latter than in the former.

Towards the end of the investigation the effects of aëration were studied. Parallel experiments were made, in one of which the septic-tank effluent was thoroughly aërated before mixing it with the nitrate, while in the other the same quantity of nitrate was added to the non-aërated effluent. In both experiments the whole of the nitrate was decomposed in twenty-four hours with evolution of the equivalent quantity of nitrogen gas. In the aërated sample no marsh gas was formed, but a considerable excess of carbonic anhydride was produced, the total volume per litre of fluid being 57·1 c.c., whereas the amount corresponding with the added nitrate *plus* the oxygen dissolved from the air was 49·8 + 5·53 = 55·33. In the non-aërated sample some marsh gas was formed, but considerably less carbonic anhydride.

The results obtained in this investigation suggest in part, at all events, an explanation of the production of free nitrogen in the 'contact' beds commonly employed in the purification of sewage. These during the period they are in contact with air no doubt become charged with nitrates, and the latter are then destroyed when the beds are filled with sewage.

II. *Cause of the Decomposition of Nitrates when in Contact with a Putrefying Liquid.*

In order to ascertain whether the action was brought about entirely by the vital processes of micro-organisms, and was not due to enzymes excreted by them or to purely chemical changes, an apparatus was devised in which the septic-tank effluent was passed through a Chamberland filter and thence into a sterilised flask

[1] Gayon and Dupetit found all three gases.

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from which it was drawn by a vacuum pump into two sterilised tubes of sufficient capacity, one of which contained a measured volume of the nitrate solution, and these tubes when filled were closed by pinch-cocks applied to indiarubber junctions. At the end of sixty-six hours analyses were made of the dissolved gases contained in the contents of both tubes, when it was found that they were practically identical, and that the nitrate had not been decomposed. The results of this experiment appear to be conclusive. The septic-tank effluent deprived of the micro-organisms which it contains has no action upon a nitrate. The decomposition of the latter must therefore be caused entirely by the vital processes of certain micro-organisms, and not by enzymic or chemical action.

III. *The Micro-organisms which reduce Nitrates with Evolution of Nitrogen Gas or Oxides of Nitrogen.*

Gayon, Springer, Deheraine, Maquenne, and others have isolated organisms from putrefying liquids which decompose nitrates with evolution of nitrogen or its oxides, but so far as can be judged from the printed abstracts of their work the identification of the species with known forms was either wanting or was incomplete. It occurred to the authors that as the action is one of reduction it would be worth while to study the effects of those micro-organisms which are known to cause the evolution of hydrogen, such as *B. Amylobacter*, *B. butyricus* (*Botkin*), *B. Lactis aërogenes*, and *B. Coli communis*, and as pure cultures of the latter happened to be available experiments were made with them.

An apparatus was constructed which permitted the introduction of pure cultures into a vessel filled with sterilised broth containing potassium nitrate from which the dissolved gases had been removed by boiling out in a vacuum.

With this apparatus experiments were first made on the action of pure cultures of *B. Coli communis* and *B. Lactis aërogenes* on broth alone. These were conducted at ordinary temperatures, and the fluid examined for dissolved gases as soon as a few bubbles of liberated gas had made their appearance. The dissolved gases were found (after removing carbonic anhydride) to consist entirely of hydrogen.

Experiments were then made with cultures of the same organisms and nitrated broth, and although they are not as yet completed the results so far obtained show that *B. Coli communis* liberates nitrogen from a nitrate in broth culture; *B. Lactis aërogenes* does not do so.

The authors desire to express their thanks to Professor Lorrain Smith, who supplied the pure cultures and gave most valuable assistance and advice during the bacteriological part of the investigation.

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8. *On a Method for the Separation of Cobalt from Nickel, and the Volumetric Determination of Cobalt.* *By* R. L. Taylor, *F.I.C.*

It has been long known that cobalt is precipitated from its solutions as a higher oxide by the carbonates of barium, strontium, and calcium, in presence of chlorine or bromine. Long ago Rose proposed this as a means of separating cobalt from nickel, but he made the mistake of using a strongly acid solution. Of course the excess of acid was neutralised by the added carbonate, but the carbon dioxide thus produced retards enormously, if it does not altogether prevent, the complete precipitation of the cobalt. The author has found[1] that if a perfectly neutral and not too concentrated solution is used, cobalt is precipitated quantitatively as a black oxide in five or ten minutes by either barium or calcium carbonate in presence of bromine water. The two carbonates appear to act equally well, but the former is to be preferred if the subsequent removal of the added metal is desired. Whichever carbonate is used it should be in the precipitated form, and it is best made into a paste with water. If the liquid from which the cobalt is to be pre-

[1] *Memoirs of the Manchester Literary and Philosophical Society*, vol. xlvi. 1902, No. 11, and vol. xlvii. 1903, No. 12.

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cipitated is acid, the acid may be neutralised by adding excess of the carbonate, but the liquid must then be well boiled to expel all the carbon dioxide, and then cooled before the bromine water is added. Not only does free carbonic acid prevent the precipitation of the cobalt, but zinc also considerably interferes with the reaction. A very small amount of that metal seriously retards the precipitation of the cobalt, and a large amount almost stops it altogether.

The author has ascertained the composition of the precipitated black oxide of cobalt by dissolving it in a mixture of hydrochloric acid and potassium iodide, and determining the amount of iodine liberated. It is fairly constant in composition, and approximates closely to the formulæ Co_9O_{14} and Co_7O_{11}. Which of these more correctly represents its composition he is unable to decide, but he suggests that its composition is sufficiently uniform to enable it to be used as a means for the volumetric determination of cobalt, by finding the amount of iodine which it liberates. The process has been tested by Mr. J. H. Davidson, B.Sc., in the assay of cobalt ores, and he finds it far more rapid than the processes generally in use, and at the same time quite sufficiently accurate for assay purposes.

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9. *Report of the Committee on Isomorphous Sulphonic Derivatives of Benzene.*—See Reports, p. 85.

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10. *Report of the Committee on Isomeric Naphthalene Derivatives.* See Reports, p. 174.

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11. *Report of the Committee on the Possibility of making Special Reports more available than at present.*—See Reports, p. 169.

FRIDAY, SEPTEMBER 11.

The following Papers and Report were read:—

1. *Investigations at Low Temperatures:*—(a) *Densities of Solid Hydrogen, Nitrogen, and Oxygen;* (b) *Methods of producing Solid Hydrogen and Nitrogen;* (c) *Latent Heats, Specific Heats, and Coefficient of Expansion of Liquid Hydrogen. By* Professor JAMES DEWAR, *LL.D., F.R.S.*

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2. *The Application of Low Temperatures to the Study of Biological Problems. By* ALLAN MACFADYEN, *M.D.*

The cellular doctrine lies at the basis of modern biological research. Living matter in its simple and complex conditions consists essentially of protoplasm with a contained body or nucleus. The two elements, plasmon and nucleus, constitute the elementary organism—the cell. The lowest individual forms of life are represented by a single cell, and such unicellular organisms may be either of a vegetable or animal type. The cells in each instance exist as free living and independent organisms. The higher forms of life are built up of parts in which the

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structural unit remains the cell, despite the modifications the cell necessarily undergoes as a fixed element in the various tissues and organs. All phases of animal and plant life are demonstrably of cellular origin and organisation, and their vital manifestations represent the summed-up activities of cells. Every vital problem therefore is ultimately a cellular problem, and a direct study of the cell, in so far as may be possible, is the keynote of the problem it is desired to investigate. A histological technique, aided by the microscope, will naturally be employed where it is desired to study the relations of parts and the structural organisation of the tissues and their cellular elements. The soluble products of the living cell spontaneously present themselves for examination by chemical and other means. It is otherwise with regard to the agencies acting and the processes occurring within the confines of the cell. These are naturally beyond the range of the ordinary methods of observation. The essential processes of life are intra-cellular and intimately bound up with the living substance of the cell, and of these but few data are possessed. The importance of the problems involved is as great as their investigation is difficult. The cell exercises its vital functions in virtue of a specific physical and chemical organisation of its molecular constituents. The ordinary methods of biological and chemical research modify or destroy this organisation, and do not admit of an intimate study of the normal cell constituents. For this purpose it is essential to eliminate or to reduce to a minimum the influence of external modifying agents on the cell or its immediate products. An intracellular physiology can only be based on a direct study of intra-cellular constituents apart from their secretions and products. This, under ordinary circumstances, is impossible, with respect to actively functionating and intact cells. It is obvious, therefore, that the first desideratum is a suitable method of obtaining the cell plasma for experimental purposes, and it is only recently that this has been successfully accomplished. The most feasible means of procedure appeared to be the use of *mechanical* agents which, whilst bringing the cell substance within the field of observation, would at the same time be least likely to affect its character and constitution. The method consists in a mechanical rupture of the cells and the release of their contents under conditions favouring the conservation of their properties. The first successful application of this description of method was made by Buchner in the particular instance of the yeast cell, and with brilliant results. The researches of Buchner were of wide biological significance, and were suggestive of much more than a cell-free alcoholic fermentation of sugars. They demonstrated the possibilities of the new methods with regard to more general vital problems. The Buchner process consisted in a mechanical trituration of the yeast cell with the aid of sand, and a subsequent filtration of the resultant mass under pressure through Kieselguhr. The filtrate contained the expressed constituents of the yeast cell which were capable of passing through Kieselguhr, and the product in virtue of its fermentative properties was termed 'Zymase.'

The writer and his colleagues have during the past four years been engaged in investigating the application of cognate methods to biological research. The advice and help generously afforded by Professor James Dewar materially forwarded the progress of the research.

It was considered that by the employment of low temperatures a disintegration of living cells might possibly be accomplished, and a wide field of inquiry opened to investigation in the biological laboratory. For this purpose the methods of mechanical trituration required refinement in several directions.

The conditions it was desired to fulfil were, a rapid disintegration of the fresh tissues and cells, an avoidance of heat and other modifying agents during the process, and an immediate manifestation of the cellular juices obtained.

It had likewise been noticed that ordinary filter pressing through Kieselguhr removed physiologically active substances from the cell juices. Liquid air appeared to be the most convenient means of obtaining the necessary cold, and it presented the advantage of a fluid freezing medium, in which the material to be manipulated could be directly immersed. The temperature of this reagent (about $-190°$ C.) would in addition prevent heat and chemical changes, whilst reducing the cells

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to a condition of brittleness favourable to their trituration without the addition of such substances as sand and Kieselguhr, which might modify the composition of the resultant product.

The method, if successful, would meet the conditions desired for the subsequent study of the intracellular juices. It may be briefly stated that by the application of low temperatures a mechanical trituration of every variety of cell *per se* has been accomplished, and the fresh cell plasma obtained for the purpose of experiment. A number of control experiments have demonstrated that immersion in liquid air is not necessarily injurious to life—bacteria, for example, having survived a continuous exposure for six months to its influence. The actual trituration of the material is accomplished in a specially devised apparatus, which is kept immersed during the operation in liquid air.

The normal and diseased animal tissues have been treated in this manner, and their intracellular constituents obtained—*e.g.* epithelium, cancer tissues, &c.

Moulds, yeasts, and bacteria have been rapidly triturated under the same conditions and the respective cell juices submitted to examination.

The severest test of the capabilities of the method was furnished by the bacteria, an order of cells for which the standard of measurement is the *mikron*. The experiments proved successful in every instance tested. The typhoid bacillus, for example, is triturated in the short space of two to three hours, and the demonstration has been furnished that the typhoid organism contains within itself a toxin. From these and other researches it has become evident that there exists a distinct class of toxins and ferments which are contained and operate within the cell or bacterium, in contradistinction to the now well-known class of toxins, which are extra-cellular—*i.e.* extruded during life from the cell into the surrounding medium. To this latter class belongs the diphtheria toxin, which has been so successfully used in the preparation of diphtheria antitoxin. A number of infective organisms do not produce appreciable extra-cellular toxins, and the search must therefore be made within the specific cells for the missing toxins to which the intoxication of the body in the course of the disease in question is probably due. The practical utility of investigating these intracellular toxins has already become evident in the preparation from the intra-cellular toxin of the typhoid bacillus of a serum having antitoxic value as regards this toxin.

The experiments made with the pus organisms have already shown that intracellular toxins exist in this important order of disease germs. The cell juices of other types of pathogenic bacteria such as the tubercle and diphtheria bacillus present characteristics of equal interest.

The application of low temperatures has aided the investigation of certain other biological problems.

The photogenic bacteria preserve their normal luminous properties after exposure to the temperature of liquid air. The effect, however, of a trituration at the same temperature is to abolish the luminosity of the cells in question. This points to the luminosity being essentially a function of the living cell, and dependent for its production on the intact organisation of the cell.

The rabies virus has not yet been detected or isolated, although regarded as an organised entity. The seat of the unknown rabies virus is the nervous system. If the brain substance of a rabid animal be triturated for a given length of time at the temperature of liquid air, its infective properties as regards rabies are abolished. This result appears to be a further indication of the existence in rabies of an organised virus.

The method described admits of a fresh study of the question of immunity from an intra-cellular standpoint.

The intra-cellular juices of the white blood-cells have been obtained, and tested with regard to bacteriolytic properties, and the natural protection that may thus be afforded to the body against the invasions of micro-parasites.

The application of low temperatures to the study of biological problems has furnished a new and fruitful method of inquiry.

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3. *Report of the Committee on securing Duty-free Alcohol for Scientific Research.*—See Reports, p. 170.

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4. *The Cause of the Lustre produced on Mercerising Cotton under Tension.* *By* JULIUS HÜBNER, *F.C.S., and* WILLIAM J. POPE, *F.R.S.*

It is generally supposed that the production of a lustre on treating stretched cotton yarn with strong caustic soda is conditioned by only two factors—namely, by the simultaneous swelling and shrinking of the fibres. The authors show, however, that a third effect is essential to the production of any appreciable silky lustre: this consists in an uncoiling of the naturally twisted ribbon constituting the cotton-fibre.

On immersing a loose cotton-fibre in strong caustic soda on the microscope stage, it is seen to rapidly untwist, to swell, and at the same time to shorten in length; the untwisting generally continues until the natural twist has nearly completely disappeared, after which the fibre presents the appearance of a round irregularly curved rod with a comparatively smooth surface. If the fibre is fixed at one end and treated with caustic soda, it twists either to the right or to the left, according as it was originally coiled towards the left or towards the right; in the most generally occurring case, that, namely, in which the fibre is coiled partly to the right and partly to the left, the untwisting attending the treatment with soda takes place first towards the left and then towards the right, or *vice versa*. If the fibre is prevented from contracting by being held at the two ends in a stretched condition it still untwists when treated with soda; since, however, the whole of the untwisting does not take place simultaneously, the untwisting of one part causes another part, which has already become unwound and attained the condition of a gelatinous rod, to become tightly twisted in the opposite direction to its original twist.

The stretched fibre thus again acquires a corkscrew-like appearance, part of the twist being right- and part left-handed, with the difference, however, that whilst the raw fibre forms a twisted ribbon creased or folded at the turns, treatment with soda converts it into a rod of circular cross-section which has been twisted whilst in a gelatinous state. The twisting of the fibre under these conditions results in the production on the rounded surface of spiral ridges possessing smooth curved contours, which reflect the light at all angles of incidence and reflection just as do the coils of a polished corkscrew. The fibre, therefore, becomes lustrous.

The high degree of transparency possessed by the cotton-fibre introduces difficulties into the microscopic examination of the changes referred to above. But although the fibre is amorphous, it is doubly refracting owing to internal strain; the authors therefore find it convenient to conduct the microscopic examination of the fibre between crossed Nicol prisms, and to accentuate the difference in tint of the various parts by introducing a one-eighth wave-length retardation plate of mica between the Nicols in such a way that its principal directions make an angle of 45° with those of the prisms. This enables the internal canal, cracks in the surface, and differences in thickness to be made out with great ease. The correctness of the explanation now given of the lustre is shown by a series of photomicrographs taken in natural colours in elliptically polarised light under the conditions just referred to. The authors have to thank their colleague, Mr. Charles W. Gamble, Director of the Photographic Department in the Manchester Municipal School of Technology, for having assisted the work by the production of these photographs. A further confirmation of the correctness of the conclusions now arrived at is afforded by the observation that whilst cotton-fibres mercerised loose have a practically circular cross-section, fibres treated under tension with soda show cross-sections shaped like polygons with rounded corners.

An independent proof of the authors' conclusions that the untwisting of the fibre is as essential a factor in the production of the gloss as are the swelling and

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the shrinking, is afforded by an examination of the action of reagents on cotton yarn. Thus, hanks of a long staple yarn having a mean breaking strength of 417·4 ± 2·1 grams were immersed loose in caustic soda (sp. gr. 1·342) and saturated barium mercuric iodide solution, and the following changes in the breaking load of the yarn and the lengths of the hanks were found to result:—

Caustic Soda.—Mean breaking load, 526·3 ± 3·8 grams; shrinkage, from 66·0 to 44·8 cm.

Barium Mercuric Iodide.—Mean breaking load, 526·6 ± 3·3 grams; shrinkage, from 66·0 to 48·9 cm.

Although the shrinkage and the increase in the breaking load brought about by these two reagents are so nearly the same, yet on immersing hanks under tension in these solutions and washing whilst still under strain the hank treated with soda acquires a brilliant lustre, whilst that treated with the iodide exhibits only a trace more lustre than the untreated yarn. The explanation of this result is found in the fact that caustic soda causes rapid untwisting of the fibre, whilst barium mercuric iodide does not cause untwisting.

The authors give a list of reagents which bring about two of the three effects shown to be essential to the production of lustre—namely, swelling, shrinking, and untwisting—and find that 'lustreing' cannot be effected with such reagents; several solutions are known, however, which cause the three effects, and with the aid of such liquids the lustre can always be produced.

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5. *Stead's recent Researches as to the Causes and Prevention of Brittleness in Steel.* *By* Professor T. TURNER, *M.Sc.*

After briefly referring to the nature of a eutectic, and the characteristic microstructure of such bodies, as pointed out by Osmond, the author outlined the structure of steel. Special reference was made to the properties and distribution of ferrite and pearlite in metal, when used in its natural state for constructional purposes, and containing about 0·45 per cent. of carbon. A short summary was then given of the work of Brinell, Heyn, Stansfield, and of Stead and Richards in reference to brittleness caused by heating steel either for a short period to a high temperature, or for a longer time at a lower temperature (900° C.). The crystalline character and brittleness so produced can be at once removed, in most cases, by heating to slightly under 900° C. The structure of steel of good quality is, therefore, largely dependent on the rate of cooling through the point Ac_1. Details were also given of the work of Stead and Richards on the production of sorbite in steel. The maximum quantity of sorbite is obtained by cooling the heated steel rapidly until its temperature is below the critical points, and then tempering either by external heat, or, in the case of rails and other similar large objects, by the internal heat of the partly cooled steel. Rails which have been rendered sorbitic in this way have a higher tensile strength and greater wearing power than ordinary rails. Sorbitic steel, when tested by repeated reversals of stress, also shows much greater toughness and endurance. A number of photographs were exhibited which showed very plainly that the microstructure of the sorbitic portion of a steel rail is quite different from that of the rest of the steel. The normal portion consists of a heterogeneous mixture of ferrite and pearlite, while the sorbitic portion is almost perfectly homogeneous.

The papers to which special reference was made were read at the Iron and Steel Institute, September 1903, and are as follows:—

1. The Burning and Overheating of Steel, by A. Stansfield.
2. The Restoration of Dangerously Crystalline Steel by Heat Treatment, by J. E. Stead and A. W. Richards.
3. Sorbitic Steel Rails, by J. E. Stead and A. W. Richards.

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6. *The Colours of Iodides.* *By* William Ackroyd, *F.I.C.*

The general law of the relation of colour to chemical constitution was stated by the author in 1892.[1] Briefly it is that in related compounds of the general formula, A_xB_y, as B increases in weight (either in atomic mass or multiple of atomic mass) there is increase of absorption of light in definite manner, so that the visible effect is progression in the metachromatic scale from the white towards the black end. With one colour vision this would appear like a gradual darkening—an aspect of the phenomenon which the author[2] regards as being presented by X rays in the photographic effects produced by them after passing through equal thicknesses of the members of a series A_xB_y. That this generalisation is reasonably fact-embracing is seen when it is stated that there are only about 2·27 per cent. of exceptions in a survey of some 616 correlated inorganic coloured compounds, and many of these exceptions are of a doubtful nature.

Iodides conform to the law; the more heavily weighted molecules have colours nearer the black end of the scale, while the lighter ones, on the other hand, come nearer the white end. Thus in vertical series of the periodic classification arsenic triiodide is orange as compared with the red of antimony and bismuth triiodides; magnesium, zinc, and cadmium iodides are white, while mercuric iodide is yellow or red. In the periodic groups there are forty-one examples of iodides; only three are apparently unconformable, two of these being doubtful exceptions.

When there is more than one iodide of the same metal we have again conformity to rule, thus:—Hg_2I_2 is olive green, and HgI_2 yellow or red.

The iodides have also a normal colour when compared with the other halides of the same radical as in the series AsF_3, $AsCl_3$, $AsBr_3$, and AsI_3. In the tabulation of these relations conformity to the law is seen both in horizontal as well as vertical groups, and 270 colour facts are presented in such a tabulation which give less than 3 per cent. of exceptions.

Finally the result of recent research shows that the element iodine has also a normal colour among the other liquid and solid halogens; their absorption increases from fluorine to iodine through the extremes of white to black.

It is amply apparent, therefore, that in a comparable series of compounds having similar molecular structure as represented by the same general formula we may have colourless or white bodies at one end and coloured substances at the other end. Hence it is contended that Professor H. E. Armstrong's view that colour is an indication of 'quinonoid structure does not hold for iodides as maintained by Miss I. Smedley,[3] nor for inorganic bodies generally.

Tables are given illustrating these various observations.

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7. *On Essential Oils.* *By* Dr. O. Silberrad.

The production of essential oils, although of extreme antiquity, has only recently been made the subject of scientific research. The earlier methods of extraction from the plants were exceedingly crude, and it was only in the early part of the nineteenth century that the industry received a new impulse by the introduction of steam distillation for the recovery of these essences. Chemical research has in recent years led to the replacement of the natural oils to some extent by products artificially prepared. As an instance of this, the author's recent discovery that carvone, $C_{10}H_{14}O$, the active principle of carraway oil, could be

[1] *Chem. News*, 1893, lxvii. 27.

[2] *On Opacity to the Röntgen Rays.* W. Ackroyd and H. B. Knowles, *Journ. Soc. Dyers and Colourists*, vol. xii. April 1896.

[3] *Brit. Assoc. Report*, 1902, p. 582.

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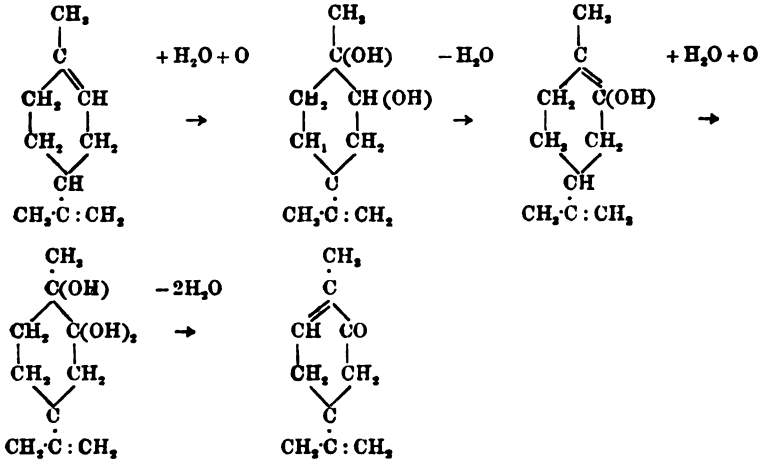
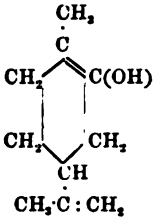
obtained direct from limonene by autoxidation was referred to. The mechanism of the reaction is probably expressed as follows:—



The above explanation is confirmed by the fact that the author has recently succeeded in isolating a monatomic alcohol as an intermediate product to which he assigns the formula



which corresponds to the hitherto unknown carveol. A specimen of the acetate of this alcohol was exhibited.

Other substances investigated by the author are the active principles of Ylang Ylang, Neroli, Carnation, and Oil of Myrrh.

The specimens shown illustrate how nearly the synthetic products approach to the natural perfumes. A new and much more economical method for the manufacture of terpineol, recently discovered by the author, was briefly referred to. One great advantage claimed for this method was that the ingredients generally considered necessary for the reaction are replaced by much less costly reagents.

The author then went on to consider the various ways of obtaining essential oils, and showed that the methods of extraction differ for the various natural oils.

(I) Turpentine, the source of terpineol, is obtained from pine trees in America by the process of 'boxing,' succeeded by steam distillation. Venetian turpentine is obtained by drilling holes in the trees, while Strasbourg and Laurentine turpentine is still collected in certain districts by means of small pointed cans.

(II) A second method is that of direct distillation from the plant, used for instance in the preparation of camphor and the recovery of camphor oil from the wood of the *Laurus camphora* in Japan. Further treatment of the distillate leads to its separation into camphor, light camphor oil (mainly pinene), phellandrene, and dipentene) and heavy camphor oil, which latter is interesting as the source of safrol, from which piperonal is now commercially obtained under the

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name of heliotropin. Investigations by the author have facilitated this conversion and very considerably reduced the cost of production of heliotropin.

The conversion of safrol to vanallin by treatment with sodium methylate and subsequent oxidation is also interesting; the chief source of vanillin is, however, eugenol, obtained from oil of cloves. Eugenol is associated in oil of cloves with a sesqui-terpene, cariophylene, from which the author has recently obtained an acid containing eleven carbon atoms.

(III) A process of expression is used for the extraction of oils which are decomposed by steam, such as bergamot (linalool acetate). The artificial preparation of this ester presents considerable difficulties, as linalool undergoes decomposition or isomerisation on coming in contact with acids and gives only very small yields of the desired esters, but investigations by the author have led to its manufacture on a commercial scale. A laboratory method whereby the difficulty may be overcome, worked out by the author, was also described, and consisted in treating a pyridine solution of the alcohol with the required acidyl chloride. The investigator of linalool has hitherto laboured under the difficulty that no solid derivative of this alcohol could be obtained. It is hoped that the author's recent preparation of a crystalline compound of linalool—the hexanitrodiphenylurethane—will be of assistance in this direction. Geraniol, an isomer of linalool, is important as the chief ingredient of otto of rose. Its acetic and butyric esters are also valuable as scents.

(IV) A fourth and very ancient method for the extraction of essential oils is illustrated by jasmine oil, which is obtained by exposing the flowers over odourless petroleum, whereby the perfume is absorbed and subsequently extracted with acetone. This oil is a mixture of a number of compounds, the distinctive odour being, however, due to jasmone, which is present to only a small extent in the oil. Peach oil contains also a large number of constituents; among these the author has isolated the ethyl ester of an undecylenic acid, the presence of which is interesting as being a case of the natural occurrence of a fatty acid containing an odd number of carbon atoms.

The sesquiterpene alcohol, santalol, from sandal-wood oil, irone from orris oil, the oxygenated products from orange oil, lemon oil, and lime oil were briefly discussed. The specimens of these various compounds illustrated their valuable properties as perfumes. A few brief remarks throughout the paper illustrated the costliness of these oils; thus it was shown that about three tons of roses were required to yield 1 lb. of otto, the cost of peach oil is between three and four times as great, whilst to prepare 1 lb. of jasmone about 200 tons of jasmine flowers would be required.

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8. *The Cholesterol Group.* *By* R. H. Pickard, *D.Sc.*

Numerous compounds of the empirical formula $C_{27}H_{44}O$ have been described and have all at some time been called cholesterins or cholesterols. Only a few of these have been well characterised, and their separate identity requires further proof.

The best known of these compounds, 'animal cholesterol,' of which the best source is human gallstones, is a very stable compound. The presence of an hydroxyl group, of at least one asymmetric carbon atom, and of an ethylene linking in the cholesterol molecule have been proved. The molecule is composed of a normal chain of nineteen carbon atoms attached to a complex nucleus.

Attempts to reduce cholesterol by chemical means were unsuccessful, but a dihydrocholesterol has been separated from human fæces.

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9. *On Acridines.* *By* Professor A. Senier, *Ph.D.*

I. *Acridines.*

In 1871 Graebe and Caro isolated from crude anthracene a yellow crystalline base, which on account of its irritating action on the skin and mucous membrane was named acridine. The base when in solution exhibited a beautiful blue

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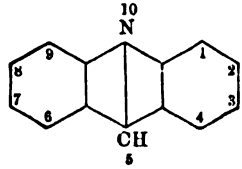
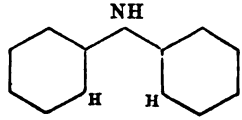
fluorescence. The subsequent researches of Graebe, Riedel, and others, led to the view now adopted of its constitution as a heterocyclic anthracene derivative of the formula

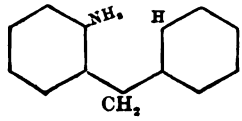


The resources of synthetical chemistry were not long in bringing to light methods for building up this interesting fluorophoric molecule from compounds of simpler structure. A phenyl derivative was first obtained and the base itself by Bernthsen and Bender in 1883.

The numerous methods which have led to the formation of acridines may be arranged into two classes—1st, those starting from diphenylamine

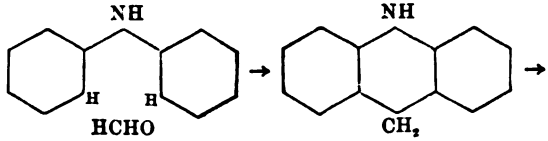


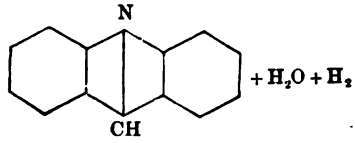
and its derivatives; and 2nd, those starting from *o*-amino-diphenylmethane



and its derivatives.

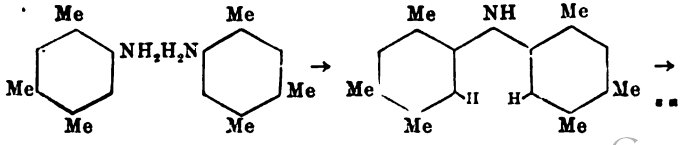
As illustrations of the first method may be taken (*a*) condensation by means of aldehydes, for example formaldehyde:—





(Unstable dihydride)

and (*b*) condensation by means of methylene diiodide; a method discovered by Mr. Goodwin and myself. For example, using ψ-cumidine the following represents the reactions which take place:—



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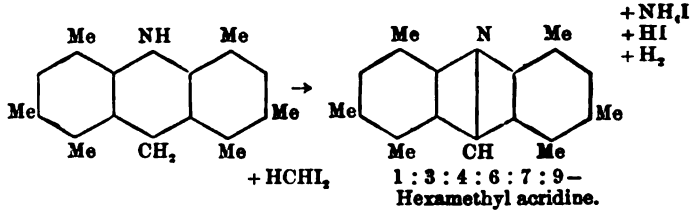
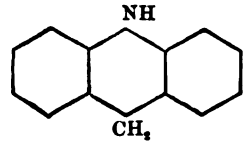
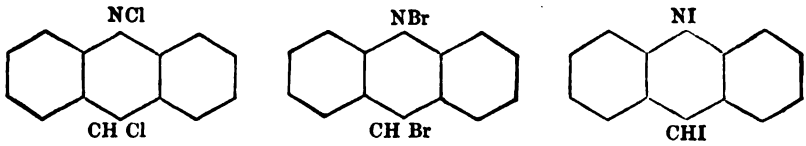


The related acridones and thio-acridones furnish an instance of ketonic and enolic tautomerism which it would be interesting to investigate by spectroscopic methods as described by Professor Hartley in his Address to this Section.

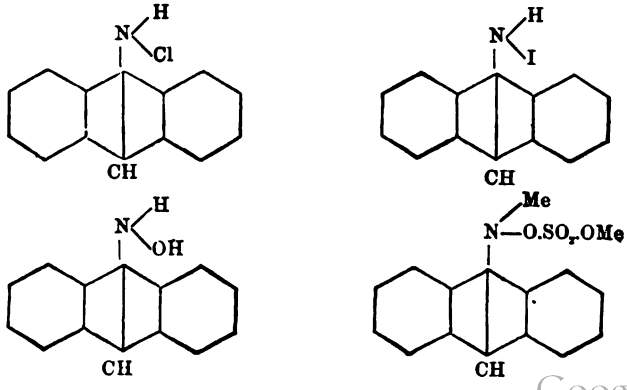
Another class of compounds formed from the acridines by the addition of two atoms of hydrogen—acridine hydrides or 'hydro-acridines'—are very unstable, and on oxidation, even by boiling with water, in some cases lose their hydrogen and revert to the original base. They are not fluorescent, a property characteristic of the acridine ring with its para linking, and may therefore have the structure:—



Mr. Goodwin and I, in an inquiry not yet quite completed, have obtained a similar class of dihalides. We have prepared chlorides, bromides, and iodides of hexamethylacridine, $\overset{\beta\,N\,\beta}{\underset{\alpha\,C\,\alpha}{|}}$-naphthacridine, and $\overset{\alpha\,N\,\alpha}{\underset{\beta\,C\,\beta}{|}}$-naphthacridine (for notation see Naphthacridines, below). Like their hydrogen analogues, these compounds are unstable and are not fluorescent. Their constitution is therefore in the case of simple acridines:—



The salts and alkhaloids of the acridines are fluorescent, and may be regarded, following Bernthsen and Bender, as true acridines with pentavalent nitrogen, thus:—



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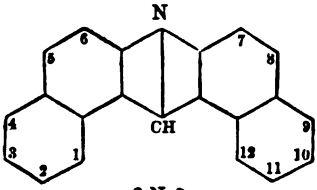
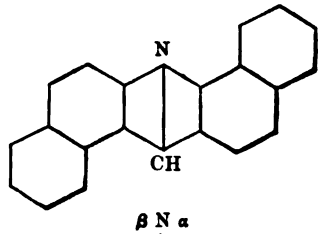
II. *Di-Naphthacridines.*

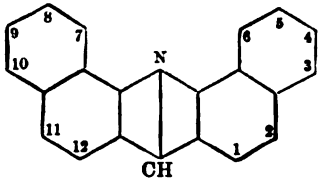
The following formulæ represent all the possible di-naphthacridines:—



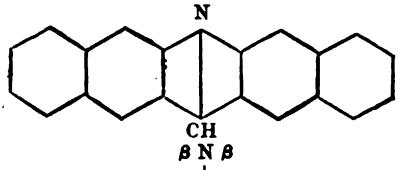
β N β
α C α
(Reed)



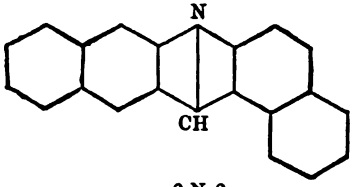
β N α
α C β
(Ullmann)



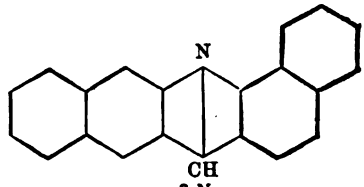
α N α
β C β
(Senier and Goodwin)



β N β
β C β
(Unknown)



β N β
β C α
(Strohbach)



β N α
β C β
(Unknown)

The notation adopted is, I think, more convenient than either that of Graebe, adopted by Ullmann, or that of Strohbach, adopted by Möhlau. The numbering is taken from Möhlau and Haase.

The naphthacridines are obtained by methods analogous to the acridines, including especially the aldehyde and the methylenediiodide reactions with naphthylamines. The naphthacridine of Reed and that just announced by Ullmann, both obtained originally by the use of formaldehyde, I have prepared by the methylenediiodide method. There is every reason to hope that the two unknown types of this group of acridines or derivatives of them will soon be discovered.

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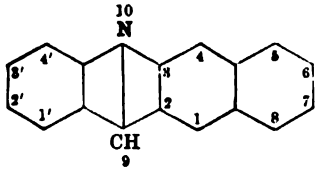
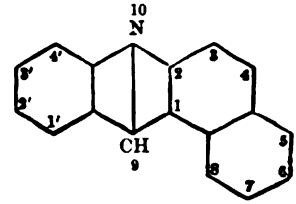
III. *Phenonaphthacridines.*

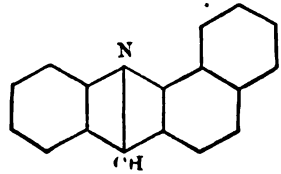
The phenonaphthacridines have been chiefly investigated by Ullmann. There are three possible types:—



N β
|
C β
(Schöpff)



N β
|
C α
(Nalband-Ullmann)



(A dihydroxyacridone of this type — Lagodzinski and Hardine)

The notation is a modification of that which I have suggested for dinaphthacridines, and the numbering is that of Ullmann.

Numerous derivatives of phenonaphthacridines are known, and they all possess the characteristic physiological properties and the fluorescence which characterise acridines generally. The remarkable tendency to the formation of the acridine grouping has recently been shown by Ullmann and Baezner. These inquirers find that alcohol may replace aldehyde in acridine synthesis, oxidation taking place in the course of the reaction.

IV. *New Experiments.*

Experiments now in progress indicate the possibility of new acridine types and also the generality of the methylene diiodide reaction. With the assistance of Miss Micklethwait I have already obtained fluorescent products indicating the formation of a *dianthracridine* and a *naphthanthacridine* and of other acridines not previously obtained by the methylene diiodide method.

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10. *Sur le Spectre de 'Self-induction' du Silicium et ses Comparaisons Astronomiques. Par le* Comte A. de Gramont, *Docteur ès Sciences Physiques.*

Plusieurs raies du silicium reconnues dans les spectres stellaires ont été considérées comme caractéristiques d'une haute température, et j'ai cru intéressant d'étudier leur manière de se comporter sous l'influence de la 'self-induction,' et de donner ici la partie du spectre susceptible de comparaisons astronomiques. Les spectrogrammes portaient à la partie supérieure, le spectre d'étincelle condensée ordinaire du silicium obtenu avec une bobine d'induction donnant 15 c/m

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d'étincelle et un condensateur de 0·009 microfarad, et en coïncidence avec ce spectre étaient photographiés successivement ceux obtenus avec des 'self-inductions' variant depuis 0·H00002 jusqu'à 0·H03000 Henry. Les spectres ont été produits avec deux prismes en flint lourd, puis avec un prisme en spathcalcite et des objectifs de quartz. Le spectre du silicium a présenté ainsi deux catégories très différentes de raies :

1° Raies résistant à une 'self-induction' de 0·H03 Henry, ou même renforcées par elle.

2° Raies commençant à s'affaiblir avec de faibles 'selfs' de 0·H0002 Henry, et disparaissant à peu près simultanément pour 0·H0062 Henry.

Subsistent avec la 'self'	α	6370	Forte.	
		6342	Forte.	
Disparaissent avec la 'self'	β	5879	Bien visible.	
		5960	Bien visible.	
Subsistent avec la 'self'	γ	5059·8	Forte.	
		5045·5	Forte.	
Disparaissent avec la 'self'	δ	4574·5	Bien marquée.	Trouvées dans les étoiles très chaudes à hélium, telles que β Crucis, ϵ Canis Majoris, Bellatrix.
		4567·0	Forte.	
		4552·5	Forte.	
	ϵ	4131·0	Très forte, diffuse.	Trouvées dans Sirius, α Cygni, Rigel, Bellatrix, ϵ Canis Majoris, Procyon, Algol, etc.
		4128·0	Très forte, diffuse.	
Plutôt renforcée par la 'self'	ζ	3905·5	Très forte, étroite. Visible dans le spectre solaire.	Trouvées dans Sirius, α Cygni, Rigel, dans les étoiles des groupes VI à VIII de la classification de Harvard College, où elles accompagnent le doublet précédent ϵ.
		3862·5	Assez forte, étroite.	
		3856·0	Forte, étroite.	
Disparaissent avec la 'self'		3835·0	Faible.	
	η	3807·0	Assez forte.	Trouvées dans ϵ Canis Majoris avec les groupes δ et ϵ.
		3796·0	Assez forte.	
		3791·5	Faible.	
		3094·5	Assez forte.	
		3087·2	Assez forte.	

Les doublets α et β ont été mesurés à la vue seulement, avec un spectroscope à vision directe. Il serait intéressant de rechercher si le groupe β accompagne les groupes δ et ϵ dans les étoiles chaudes.

Le triplet δ (4574 à 4552) avait été reconnu par M. E. Demarçay [1] comme appartenant au silicium en solution fluorhydrique, et par moi-même [2] avec le silicium libre, et dans les silicates fondus. Malgré cela ces mêmes raies, rencontrées par divers observateurs dans les spectres des étoiles, n'avaient pas été encore attribuées au silicium jusqu'en 1900, où M. Joseph Lunt [3] a identifié à son tour leur origine.

Le doublet ϵ (4131 ; 4128) est considéré par Sir Norman Lockyer comme les plus remarquables 'enhanced lines' du silicium. Sous l'influence de la self elles sont les dernières à disparaître ; les spectrogrammes montrent qu'elles se raccourcissent en se concentrant au voisinage des électrodes, se réduisent à des points et s'évanouissent pour une 'self' de 0·H0062 Henry.

La raie 3905 du triplet ζ est très forte avec la 'self' maximum employée (0·H03), tandis que les deux raies voisines, 3862 ; 3856, à peine visibles pour 0·H0006, ont disparu avant d'atteindre 0·H0062.

[1] *Spectres Electriques*. Paris : Gauthier-Villars. 1895.

[2] 'Spectres des Métalloïdes dans les Sels Fondus : Silicium,' *Comptes Rendus de l'Acad. des Sciences de Paris*, 25 janvier 1897.

[3] *Roy. Soc. Proceed.* vol. lxvi. p. 44.

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Le triplet η (3807 à 3791) paraît s'effacer pour une 'self' plus faible encore.

La partie plus réfrangible du spectre ne présente plus d'intérêt astronomique, car elle est arrêtée par l'absorption atmosphérique. Je l'ai étudiée avec un spectrographe à partie optique toute en quartz; la raie 2542 disparaît pour les mêmes valeurs de 'self-induction' que ci-dessus, c'est-à-dire pour moins de $0{\cdot}^{H}0062$. Toutes les autres lignes, notamment le groupe caractéristique de six raies (2529 à 2507) et le groupe (2217 à 2208), résistent absolument à la 'self-induction' maximum. J'ai enfin reconnu que la ligne extrême 1930·0 n'appartient pas au silicium mais bien à l'aluminium.

Ces recherches ont été faites avec du silicium cristallisé en petits octaèdres et en lamelles, puis avec le silicate de sodium fondu au chalumeau, sur des fils de platine. Comme je l'avais déjà signalé [1] l'action de la 'self-induction' est la même sur les corps solides ou les sels fondus.

Les longueurs d'onde ont été mesurées par comparaison avec celles des raies d'un alliage plomb-cadmium, photographiées sur chacun des spectrogrammes.

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11. *The Theory of Dyeing.* *By* Professor G. von Georgievics.

The author gives a brief historical introduction to the subject of tinctorial chemistry, and observes that the study of this branch of applied science has been greatly complicated by the publication of large masses of incompletely observed facts. He further remarks that practical unanimity prevails as to the nature of the dyeing process in so far as concerns the application of colours such as chrome yellow, nitraniline red, and the mordant colours; these colours, or compounds of the colours with the mordant, are deposited as such upon the fibre.

The theories, or, more properly, the hypotheses, concerning the nature of dyeing refer more particularly to the so-called substantive colours—that is, to dyeing with acid colours, basic colours, and direct colours. The principal theories of the process of dyeing are two in number—namely (1) the chemical theory, and (2) the mechanical theory. In accordance with the first, the dyeing of wool and silk with basic and acid colours is due to the formation of chemical compounds between the colour and the fibre; the chemical combination is supposed to be of a loose, salt-like nature, because the combined colour exhibits a chemical behaviour identical with that of the free colour.

The chemical theory offers no plausible explanation of dyeing with direct cotton colours (salt colours).

The mechanical theory describes the process of dyeing as one of absorption or of solution. Some writers attempt to compromise by describing the dyeing process as partly chemical and partly mechanical in nature, whilst others are of the opinion that the dyeing changes in character with the dye-stuff and the fibre.

In discussing what is required of a theory of dyeing, the author states the view that such a theory can be nothing more nor less than an expression of all the hitherto known facts concerning the process. The supporters of the mechanical theory of dyeing do not deny the possibility of the existence of chemical combination, more especially as all colours are of acid or basic nature, and the animal textile fibres, at least, are not chemically indifferent; they claim, however, that the existence of such a chemical combination has not been hitherto proved in any single case, whilst all the observed facts tell in favour of the chemical theory. The supporters of the chemical theory of dyeing put forward as specially important pieces of experimental evidence two statements, both made by E. Knecht, the one referring to the dyeing of basic colours on wool and silk, the other to dyeing with acid colours. In accordance with the first statement, wool and silk play the part of acids towards basic colours, and the corresponding coloured compounds must be regarded as salts of the colour with keratin or fibroin respectively, because in such dyeing processes the acid is quantitatively split off from the colouring matter and only the colour base is taken up by the fibre. It is further suggested that the

[1] *Comptes Rendus de l'Acad. d. Sciences d. Paris*, 5 et 26 mai 1902.

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colourless rosaniline base can only give rise to the fuchsine-red colour by formation of a salt.

Since this time, however, the author has shown that in dyeing chemically indifferent substances, such as glass and china-clay, which cannot play the part of acids, the acid of the basic colour remains quantitatively in the dye-bath; he has further shown that the rosaniline base exists in a coloured form. The full force of this contradiction of the chemical theory is not admitted, it having been objected that many kinds of glass are slightly attacked by water, and are thus not chemically indifferent. The author showed many years ago, however, that this objection is founded upon a total disregard of the fact that the results are of a quantitative nature.

The author remarks that whilst the attack has been directed against the strong part of his work, its weak point—which is as follows—has not hitherto been noticed. The fact that in the dyeing of chemically indifferent substances with basic colours the acid part of the latter remains quantitatively in the bath is only a proof that one has to deal with the same phenomenon which is observed in the dyeing of silk and wool, and is not an indication that salt formation has taken place between the colour base and the fibre substance; the dyeing of glass and china-clay is, at any rate, a process of absorption, and its external similarity with the dyeing of silk and wool with the same colours is not necessarily a proof of the identity of the two processes. The author's work was directed solely against the validity ascribed to the argument repeatedly brought forward in support of the chemical theory, and still leaves open the question of the nature of the processes concerned in the dyeing of animal fibres with basic colours. Should it ever be possible to prove the existence of chemical compounds between colour and fibre, it will be most probably done in the case just referred to, but such information could certainly not be obtained in the manner only lately attempted by Knecht.

Knecht boiled out with alcohol wool and silk dyed with night-blue, and believed himself forced to the conclusion that the extract contained chemical compounds of the night-blue base with keratin or fibroin respectively. If the conclusion were correct, it would be possible, by prolonged repetitions of the operations of dyeing and extraction with alcohol, to bring about a gradual destruction of the fibre. The improbability of this is obvious, and the author clearly proves the incorrectness of Knecht's final conclusions by repetition of the work upon which they are based. After precipitating the colour base and eliminating the alcohol, Knecht prepared aqueous solutions from the above-mentioned alcoholic extracts, which, according to his statement, possessed the property of precipitating magenta and night-blue, and which he therefore supposes to contain keratin or fibroin respectively, or chemical compounds formed from these two substances during the process of dyeing. On repeating these experiments the author finds that the solutions, if perfectly pure fibre material purified with alcohol has been used, precipitate solutions of magenta only, and that but very slightly indeed. The same precipitate may, however, be obtained if wool and silk are entirely left out of the experiments; he finds that, by precipitating the colour base from an alcoholic solution of night-blue with barium hydrate and by afterwards removing the latter from the solution, a liquid is finally obtained which has the property of precipitating a solution of magenta.

In this instance it is naturally quite out of the question that keratin or fibroin play any part in the precipitation.

The second principal support upon which the chemical theory rests has also been given by Knecht. It was observed at an early date that molecular proportionality between colour and fibre seems non-existent in dyeing trials; the results thus differ from those obtained in cases of ordinary chemical combination. By dyeing wool in very concentrated solutions of picric acid and similar acid colours, Knecht supposed that he had established the existence of chemical compounds formed in definite molecular proportions. The repetition of these experiments by Perger and Ulrich has, however, shown that Knecht, in his desire to make the fibre take up as large a quantity of the colour as possible, used such an excess of colour that part of it was deposited as crystals upon the dyed fibre. It is therefore

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clear that under such conditions it is absolutely impossible to ascertain, even with a small degree of accuracy, the amount of colour which has been actually taken up by the fibre.

The author considers himself justified in stating that these two fundamental supports upon which the chemical theory of dyeing rests cannot withstand any searching criticism.

A considerable number of facts have accumulated during recent years which tend to strengthen the view that the processes of dyeing are uniform and of a mechanical nature. The author showed in 1894 that, in dyeing silk with indigo-disulphonic acid, the distribution of the colour between the residual solution and silk dyed in it is governed by a law which may be expressed by the formula

$$\frac{\sqrt{\text{C in solution}}}{\text{C in fibre}} = \text{K},$$

in which C refers to the concentration of the colour solution and K is a constant independent of the concentration. Later experiments have shown that this law of the distribution of the colour is applicable to dyeing on silk and wool of other acid colours, and also to the dyeing of direct cotton colours (salt colours) on cotton. It is thus proved, first, that the processes of dyeing with the acid colours on the one hand and with the direct cotton colours on the other are identical in kind; and, secondly, that these processes cannot be of a chemical nature. If a chemical compound were formed, the distribution of the colour between the two media would be of an entirely different character, just as Walker and Appleyard have recently indicated. The author has only lately shown that picric acid and oxyazobenzene are deposited on the fibre in a free state during dyeing with these colours: this seems to be of especial importance in the case of picric acid, in view of Knecht's statement, recalling the fact that picric acid forms compounds with such great readiness; chemical combination, if at all possible, might have been expected in this instance.

Binz and Schröter have lately endeavoured to show that dyeing with oxyazobenzene differs materially from that of the other acid colours. On account of the fastness exhibited by dyeings with oxyazobenzene these authors assumed that this colour forms a stable compound with the substance of the wool as the result of condensation.

As regards the dyeing of acid colours on animal fibres, and that of the direct cotton colours on cotton, we may therefore safely say that we possess distinct proof that these processes are identical and of a mechanical nature.

The further question as to whether substantive dyeings should be considered as solid solutions or as resulting from adhesion is still open for speculation.

MONDAY, SEPTEMBER 14.

The following Papers and Report were read:—

1. *The Slow Combustion of Methane and Ethane.*
By WILLIAM A. BONE, *D.Sc., Ph.D.*

I may perhaps be allowed to explain my reasons for reopening what I am well aware is one of the most controverted questions in the whole domain of Chemistry. Let me say at once that I have no new general theory of hydrocarbon combustion to bring forward; but during the past three or four years I have, in conjunction with two of the research students at Owens College,[1] been engaged upon an investigation on the slow combustion of methane and ethane at temperatures below their ignition-points, the results of which throw some new

[1] Messrs. R. V. Wheeler and W. E. Stockings.

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light on the question at issue. It is my intention to extend the work to other typical hydrocarbons in the hope that the gradual accumulation of experimental facts may at some future time provide a sure basis for a general theory of hydrocarbon combustion. Meanwhile, it seemed to me that the meetings of the Chemical Section afforded a fitting opportunity of communicating and discussing these new observations, of obtaining suggestions for future work, and possibly, also, of arranging some form of co-operation among those workers who are specially interested in this field of inquiry.

It seems to me unnecessary to make more than a passing reference to the theories which up to the present have been advanced to explain the mechanism of hydrocarbon combustion. I must, however, say a word with regard to two of them which involve the idea of the '*preferential*' combustion, either of hydrogen or of carbon. The older idea, that in a defective oxygen supply the hydrogen of a hydrocarbon burns preferentially to the carbon, is unsupported by experimental evidence, and I suppose now hardly finds acceptance among chemists at any rate. On the other hand, the opposite view, that the carbon burns preferentially to the hydrogen, was put forward, originally by Kersten in 1861 I believe, to explain the well-known fact that when such a hydrocarbon as ethylene is exploded with just sufficient oxygen to burn the carbon to carbon monoxide, the cooled products consist of carbon monoxide and free hydrogen—

$$C_2H_4 + O_2 = 2CO + 2H_2.$$

Professor Smithells in 1892 was led to indorse this view as the result of his analyses of the interconal gases of hydrocarbon flames.

It seems to me that the idea of '*preferential combustion*,' whether of hydrogen or of carbon, is closely allied to the old doctrine of '*elective affinity*,' and that it is hardly to be reconciled with modern conceptions of the nature and conditions of chemical change in a homogeneous system. Furthermore, it may be pointed out that the evidence usually adduced in support of the contention that carbon burns preferentially to hydrogen is wholly derived from experiments on the oxidation of hydrocarbons at very high temperatures, either in the flame, or in the explosion wave. Under these conditions it is practically impossible, by any means at our command at present, to distinguish the character of the *primary* oxidation in the case of a hydrocarbon, for since the velocities of all the reactions concerned are enormously great, the final state of equilibrium is almost instantaneously established.

The experiments on the slow combustion of methane and ethane, which have led me to make this communication, have been carried out at temperatures far below the ignition-points of the gases—that is to say, at temperatures where the oxidation velocities are sufficiently small to allow of their being easily measured. It is also important to observe that either of the hydrocarbons in question interacts with oxygen at temperatures below those at which the velocities of any of the undermentioned possible secondary changes become appreciable:—

(i) $2H_2 + O_2 = 2H_2O$.
(ii) $2CO + O_2 = 2CO_2$. (moist)
(iii) $CO + H_2O \rightleftarrows CO_2 + H_2$.
(iv) Reduction of CO_2, or of H_2O, by carbon.

Therefore, by suitably choosing our temperature conditions we have been able to exclude the possibility of these reactions occurring, and so to prevent the complete masking of the *primary* reaction by secondary changes.

The details of these experiments either have been, or shortly will be, published elsewhere,[1] and we need therefore only here indicate the general character of the results.

In the first place, we should say that the mixtures of methane (or ethane) and oxygen employed usually contained just sufficient oxygen to burn the carbon of

[1] *Trans. Chem. Soc.* (1902), **81**, 535; **83**, 1903.

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the hydrocarbon to carbon monoxide (*e.g.* mixtures of two volumes methane with one volume oxygen, or of equal volumes of ethane and oxygen).

The lowest temperature at which such mixtures of methane and oxygen interact, when sealed up in a borosilicate glass bulb at atmospheric pressure, and afterwards placed in a constant temperature air-bath, is somewhere about 300°; in the case of the mixtures of ethane and oxygen it is about 225°. At all temperatures ethane is oxidised much more rapidly than is methane, other conditions being equal.

Under such conditions a portion of the hydrocarbon is burnt to, finally, carbon dioxide, carbon monoxide, and steam, *without any liberation of free hydrogen or separation of carbon*, while a portion of the original hydrocarbon always remains intact.

Below are tabulated the analyses of the products from two typical experiments:—

Products from mixture $CH_4 = 66{\cdot}9$, $O_2 = 33{\cdot}1$, *maintained* 7 *days at* 350°.		*Products from mixture* $C_2H_6 = 49{\cdot}8$, $O_2 = 50{\cdot}2$, *maintained* 15 *hours at* 250°.	
CO_2	14·0	CO_2	15·9
CO	16·3	CO	41·2
O_2	0·9	O_2	nil
CH_4	68·8	C_2H_6	42·9
Per cent. contraction in volume on opening cooled bulb under mercury	nearly 32·0		34·76

We next devised an apparatus in which the reacting gaseous mixtures can be continuously circulated day and night, at a practically uniform rate, (1) over a surface maintained at a constant temperature; and (2) through suitable washing and cooling arrangements for the removal of soluble or condensable intermediate products. A manometric arrangement enables us to take pressure records of the gas in the apparatus at regular time-intervals throughout a given experiment, which may often extend over many consecutive days and nights. The records so obtained show, in the case of both methane and ethane, a regular and continuous fall of pressure throughout the oxidation.

The experiments with methane reveal the fact that formaldehyde plays an important *rôle* as an intermediate product; that, indeed, the oxidation involves at least two distinct stages, namely:—

1. A primary oxidation to formaldehyde and steam—

$$H \cdot \overset{H}{\overset{|}{C}} \cdot H + O : O = H \cdot \overset{H}{\overset{|}{C}} : O + H_2O$$

2. The subsequent further rapid oxidation of the formaldehyde to carbon monoxide, carbon dioxide, and steam. This may best be considered as the result of two simultaneous reactions, namely:—

$$(a)\quad H \cdot \overset{H}{\overset{|}{C}} : O + O : O = O : C : O + H_2O$$

$$(b)\quad H \cdot \overset{H}{\overset{|}{C}} : O + O : O + H \cdot \overset{H}{\overset{|}{C}} : O = 2CO + 2H_2O.$$

Possibly the latter may involve the formation and very rapid decomposition of formic acid. Thus

$$O : \overset{H}{\overset{|}{C}} \cdot H + O : O + H \cdot \overset{H}{\overset{|}{C}} : O = 2\left[O : \overset{H}{\overset{|}{C}} \cdot OH\right] = 2CO + 2H_2O.$$

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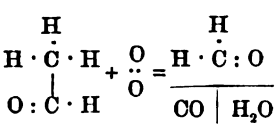
In the case of ethane we are able to distinguish the successive formations of (1) acetaldehyde, and (2) formaldehyde, as intermediate products. The experimental results are consistent with the following view of the case, namely:—

1. That the primary oxidation involves the formation of acetaldehyde and steam—

$$CH_3 \cdot CH_3 + O_2 = CH_3 \cdot CHO + H_2O.$$

2. That the acetaldehyde is further rapidly oxidised to carbon monoxide, steam, and formaldehyde—



3. That the formaldehyde suffers further oxidation as indicated above.

These views, it may be stated, are supported by experiments on the oxidation of acetaldehyde.

I wish it to be understood that I have provisionally adopted the explanations just given of the oxidation stages of methane and ethane as a convenient working hypothesis because they express most simply the observed facts. Professor Armstrong has recently given us [1] a very suggestive general theory of combustion which embodies his dictum that chemical interchange and electrolysis must be regarded as interchangeable equivalent terms. Applied to hydrocarbons (*e.g.* methane) the theory involves the successive 'hydroxylation' of each hydrogen by an indirect process, the oxygen being transferred electrolytically across 'conducting' water, as indicated by the following scheme:—

$$(1)\ CH_4 + OH_2 + O_2 = CH_3(OH) + H_2O_2$$
$$(2)\ CH_3OH + OH_2 + O_2 = CH_2(OH)_2 + H_2O_2$$
$$(3)\ CH_2(OH)_2 + OH_2 + O_2 = CH(OH)_3 + H_2O_2$$
$$(4)\ CH(OH)_3 + OH_2 + O_2 = C(OH)_4 + H_2O_2$$

The hydrogen peroxide formed being in part decomposed by heat, and in part acting as depolariser.

The hydroxylated molecules thus produced may decompose, as for instance:—

$$(5)\ CH_2(OH)_2 = \underset{\text{formaldehyde}}{CH_2O} + H_2O;$$

and then the formaldehyde is further indirectly oxidised to (1) formic acid (2) carbonic acid, thus:—

$$(6)\ O:C:H_2 + OH_2 + O_2 = \overset{HO}{H}\!>\!C:O + H_2O_2$$

$$(7)\ \overset{HO}{H}\!>\!C:O + OH_2 + O_2 = \overset{HO}{HO}\!>\!C:O + H_2O_2$$

The formic and carbonic acids thus produced then decompose, as follows:—

$$(8)\ \overset{HO}{H}\!>\!C:O = CO + H_2O$$

$$(9)\ \overset{HO}{HO}\!>\!C:O = CO_2 + H_2O$$

It does not come within the province of this paper to discuss this electrolytic theory of chemical change; it should, however, be pointed out that Professor Armstrong's views demand the formation of an alcohol in the *primary* oxidation of a saturated hydrocarbon. Although I have never failed to obtain a marked

[1] *Trans. Chem. Soc.* 1903, **83**, 1088.

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formation of aldehydes in my experiments on methane and ethane, I have so far searched in vain for alcohols; if the latter are produced during the primary oxidation, they are very rapidly further oxidised to the corresponding aldehyde, which must be presumed to be more stable under these conditions.

The question now arises whether these reactions which undoubtedly occur at low temperatures also occur at the higher temperatures of hydrocarbon flames. My own view is this: the velocities of these 'low temperature' reactions will rapidly increase as the temperature rises, and so long as aldehydes can exist, aldehyde formation will occur. But aldehydes themselves decompose at high temperatures; thus acetaldehyde is known to yield carbon monoxide and methane—

$$CH_3 \cdot CHO + CH_4 + CO$$

and similarly formaldehyde yields carbon monoxide and hydrogen—

$$H \cdot CHO = CO + H_2$$

and possibly within certain temperature limits these reactions are reversible.

The production of formaldehyde in the oxidation of methane, for example, will only be limited by the temperature at which formaldehyde is incapable of existence, whatever that may be.

We shall have to take into account similar considerations in discussing other probable changes, as, for example, (1) the further oxidation of aldehydes, and (2) the purely thermal decomposition of hydrocarbons. All these possible reactions call for further careful investigation. As yet we have so few well-established data that it seems premature to formulate general theories. The subject is very complex, and is beset with many and great experimental difficulties, but it is surely within our power to overcome them, especially if a sufficient number of workers will co-operate.

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2. *Fluorescence as related to the Constitution of Organic Substances.* By JOHN THEODORE HEWITT.

A distinction must be made between substances which are simply coloured and those which exhibit the phenomenon known as fluorescence. Whilst both classes of substances select radiant energy of certain wave-lengths, the fate of this energy is different in the two cases. A merely coloured substance degrades the energy it absorbs to a confused mixture of relatively slow vibrations, so that the substance or its solution tends to rise in temperature. A fluorescent solution largely transforms the absorbed energy and emits it with an altered frequency, in most cases still sufficiently high for the emitted energy to appear as light.

Both the absorption and the fluorescent spectrum are composed of bands which in the fluorescent spectrum are usually broader than in the absorption spectrum. Dark-line absorption spectra or bright-line fluorescent spectra are not to be expected in the case of a solution; the molecules of the solvent must exert an influence on the vibrations of the molecules of dissolved coloured substance, and, this influence not being uniform for all the molecules of dissolved substance, both spectra can only be expected to consist of bands and not of lines.

In the case of a gas the emission spectrum varies with the pressure; should the gas be sufficiently rarefied, the molecules perform their vibrations in an unfettered manner and the spectrum consists of bright lines corresponding to definite rates of vibration. But on increasing the pressure of the gas the molecules must mutually influence one another, with the result that their rates of vibration are affected. Since at any instant different molecules will not be affected to the same extent, they will execute their vibrations at somewhat varying rates and the lines in the spectrum will broaden into bands. A fluorescent-line spectrum could only be found in the case of a gas; whether any sufficiently fluorescent rarefied gas exists appears very doubtful.

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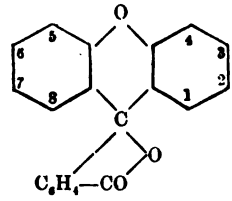
The ultimate cause of fluorescence has naturally attracted attention. Stokes[1] was inclined to attribute a peculiar sensibility to the molecules of substances exhibiting this phenomenon. Lommel[2] started with the assumption that light of a certain frequency may give rise to vibrations of varying amplitudes in the molecules of a substance. If the frequency depends on the amplitude, the emitted light will not be homogeneous and the substance may be considered as fluorescent. Two grave objections to Lommel's theory are, that there seems to be no possibility of a source of light remaining homogeneous whilst it fades in intensity, and that all coloured substances should be fluorescent. Both deductions are at variance with actual facts.

Fluorescence must of necessity attract the attention of organic chemists, chiefly on account of the fact that so many fluorescent substances are organic compounds of known constitution. Richard Meyer[3] attempted to connect the fluorescence of organic dyestuffs with the presence of certain atomic groupings which he termed 'fluorophors.' Amongst such fluorophors, the pyridine, pyrone, and paradiazine rings may be mentioned. For fluorescence to be developed it is necessary that the fluorophor be attached to heavy carbon groups, usually aromatic nuclei. Meyer's theory gives no explanation of the influence of solvents and of the differences frequently observed in the case of isomeric compounds.

The present author[4] has started from a fundamentally different point of view, which may be stated as follows. If in the case of a tautomeric compound the passage from one to the other configuration can be effected by two equal but opposite atomic displacements, the molecules will vibrate between the two extreme positions of less symmetry, passing through the intermediate more symmetrical configuration. Energy absorbed when the molecules possessed one configuration could then be emitted when they had the other configuration; and as the two configurations would certainly correspond to different vibration frequencies, one has the necessary conditions for the exhibition of fluorescence.

Consider the fluorescence phenomena in the case of the following compounds:—

I. *Fluoran*,[5] $C_{20}H_{12}O_3$,



II. 3·6-*Dihydroxyfluoran* or *Fluoresceïn*, $C_{20}H_{12}O_5$.
III. *Tetrabromofluoresceïn* (*Eosine*), $C_{20}H_8Br_4O_5$.
IV. *Tetraiodofluoresceïn*, $C_{20}H_8I_4O_5$.
V. 4·5-*Dinitrofluoresceïn*,[6] $C_{20}H_{10}(NO_2)_2O_5$.
VI. 4·5-*Dinitro*-2·7-*dibromofluoresceïn*,[7] $C_{20}H_8(NO_2)_2Br_2O_5$.
VII. 2·7-*Dinitro*-4·5-*dibromofluoresceïn*,[7] $C_{20}H_8(NO_2)_2Br_2O_5$.

Of these substances, I. is colourless, and in neutral solvents gives colourless, non-fluorescent solutions. It fluoresces, however, if dissolved in strong sulphuric acid. II. III. and IV. all fluoresce, especially in alkaline solution.

The alkaline solutions of V. VI. VII. do not fluoresce at all. Meyer's theory gives no explanation of these differences. The theory now brought forward agrees

[1] *Phil. Trans.*, **1852**, 463.
[2] *Wied. Annalen*, **3**, 268.
[3] *Zeitschr. physikal. Ch.* (1897), **24**, 468.
[4] *Proc. Ch. Soc.* (1900), **16**, 3; *Zeitschr. physikal. Ch.* (1900), **34**, 1–19.
[5] *Berichte* (1891), **24**, 1412; (1892), **25**, 1385; *Annalen* (1882), **212**, 349.
[6] *J. Chem. Soc.* (1900) **77**, 1324; (1902), **81**, 893.
[7] *Ibid.* (1902), **81**, 893.

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with the observed facts. Fluoran, though not itself tautomeric, might give tautomeric fluorescent oxonium salts; these have been isolated. The non-fluorescence of the nitro-derivatives of fluoresceïn is readily explained; the nitro-groups enter into the ortho-positions to the hydroxyl groups, and since compounds of the type —$C(NO_2)=C(OH)$—yield sodium salts which are, in all probability, of the general formula—$C(NO_2Na)-CO$—the fluorescence which depends on a doubly symmetrical tautomerism is necessarily inhibited.

Whilst in the greater number of cases the theory propounded agrees with the observed facts, exceptions such as the following must not be overlooked.

1. Substances having the necessary constitution, but not exhibiting fluorescence.

A secondary tautomerism might inhibit the vibration between two extreme similar configurations; this case has been considered in dealing with the nitro-derivatives of fluoresceïn.

In some cases it is possible that fluorescence has not been detected owing to the emitted radiant energy corresponding to an invisible part of the spectrum.

Another cause which may preclude the necessary vibration is that the symmetrical intermediate configuration may correspond to more molecular free energy than the extreme unsymmetrical configurations. The molecule would then have no tendency to vibrate regularly, the case being analogous to that of an inverted pendulum.

2. Substances which fluoresce but cannot possess doubly symmetrical tautomeric formulæ.

The author does not think the occurrence of such substances can be taken as a serious argument against his theory, which may be formulated as follows:

If the molecules of a tautomeric substance possess such a structure that the passage from the configuration of least free energy to the less stable configuration may be effected by equal and opposite atomic displacements, the molecules will vibrate between the extreme positions and the substance exhibit the phenomenon of fluorescence.

That fluorescence may be due to other causes is not negatived by this assertion.

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3. *Preliminary Note on some Electric Furnace Reactions under High Gaseous Pressures.* *By* J. E. Petavel *and* R. S. Hutton.

The paper gives an account of some work carried out in an inclosed electric furnace constructed to work with gaseous pressures up to 200 atmospheres. The power employed has been usually about 15 kilowatts per hour, the furnace containing a charge of about 20 lb. of material and 1,000 to 2,000 litres of gas. A second furnace of about one-tenth the capacity was used for gas reactions with high-tension current.

The reactions at present under investigation include the direct reduction of alumina by carbon, the conditions of formation of calcium carbide, particularly as modified by the change of gaseous atmosphere, and the formation of graphite. With regard to gaseous reactions a study of the production of nitric acid and cyanogen compounds has already been commenced.

The preliminary experiments have shown that under pressure alumina is reduced to the metallic condition, but in all cases accompanied by a large amount of aluminium carbide. This reaction is most unfavourably influenced if the carbon monoxide which is formed be retained, whereas it is favoured by the rapid removal of the gaseous products of reaction. So far as calcium carbide is concerned, contrary to expectation, the yield is in no way diminished by the presence of carbon monoxide gas even at high pressures. An important difference in the methods of working is necessary in those cases where it is desired to effect purely gaseous reactions. Here a high-tension current is required. For instance, the formation of nitric acid, even at pressures of 100 atmospheres, is only accomplished in appreciable amount where the electromotive force used is of several thousand volts.

The account includes a general description of the plant employed for preparing and compressing the various pure gases required in quantity for this work.

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4. *The Atomic Latent Heats of Fusion of the Metals considered from the Kinetic Standpoint.* By HOLLAND CROMPTON.

According to the kinetic theory, if a fluid is composed of monatomic molecules, the kinetic energy given to the particles of the fluid on heating, if no external work is done, is equivalent to $2{\cdot}96 \times T$ calories for the gram-molecule. If it is assumed that in the solidification of such a fluid the process consists mainly in bringing the molecules (in this case atoms) to rest, or in largely restricting their motion, kinetic energy approximately equivalent in amount to $2{\cdot}96 \times T$ calories should be lost by the gram-molecule. Hence in the above case the molecular (atomic) latent heat of fusion Ar should approximate to $2{\cdot}96 \times T$ calories, or $Ar/T = 2{\cdot}96$.

As a matter of fact, the values of Ar/T in the case of fourteen different metals, presumably of monatomic structure, vary between 1·82 for potassium and 3·05 for tin, the average value being 2·4. Up to the present only two cases have been met with among the metals in which the determined values of r do not bring Ar/T within these limits, these being gallium and bismuth, for which the values of Ar/T are 4·67 and 4·82 respectively.

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5. *The Influence of Small Quantities of Water in bringing about Chemical Reaction between Salts.* By EDGAR PHILIP PERMAN, *D.Sc.*

Many experimenters have investigated the influence of traces of moisture in reactions between gases, but so far as I am aware no one has hitherto made similar experiments with solids.

The substances chosen for experiment were salts of lead or mercury, and salts of potassium, usually the iodide, which would show the occurrence and progress of a reaction by a colour change.

a. Experiments with Lead Chloride and Potassium Iodide.—Equivalent quantities of the two salts were dried over strong sulphuric acid in a suitable apparatus, and then mixed; it was found that after forty-eight hours' drying no visible change took place on mixing the salts, but on keeping the mixture for a week (in a sealed flask) a faint yellow colour appeared, which gradually deepened, until after some months it became a bright yellow.

Attempts were made to discover how much water was necessary in order to make the reaction immediately visible; the results were not very concordant, but indicated about ·5 mg. as the amount necessary in the conditions of the experiment, viz. two grams of potassium iodide and an equivalent quantity of lead chloride were mixed in a glass flask of about 100 c.c. capacity.

b. Experiments with other Lead Salts and Potassium Iodide.—Lead formate and lead nitrate were found to act in a similar way to the chloride.

Lead sulphate reacts much more slowly, although exposed to the air, while the carbonate and the oxide react very slowly indeed.

c. Experiments with Mercuric Chloride and Potassium Iodide.—Mercuric chloride and potassium iodide treated in exactly the same way as already described gave a strong red coloration on mixing; the same result was obtained when commercial phosphoric anhydride was used as a drying agent. By drying with specially prepared phosphoric anhydride, however, the mixture obtained has been kept for some months without change.

d. Other Experiments with Mercuric Salts.—Mercuric cyanide showed no reaction with potassium iodide.

Mercuric chloride and potassium chromate reacted very slowly, although exposed to the air.

Discussion of Results.—There is no reason for thinking that these reactions take place in any way essentially different from similar reactions in solution, and I believe that the only difference is the extreme slowness of the reaction. It is

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noteworthy that the velocity of the reaction between mercuric chloride and potassium iodide is enormously greater than that between lead chloride and potassium iodide when dried in the same way. The factors to which this difference may be referred are (1) solubility, (2) volatility, (3) degree of ionisation, (4) specific reaction velocity. We will consider these in order.

(1) Mercuric chloride is about ten times as soluble as lead chloride in cold water, but this alone would not account for the difference; *e.g.* mercuric cyanide is still more soluble, but does not react at all.

(2) Judging from the boiling-points, mercuric chloride would appear to be more volatile than lead chloride, the boiling-point of the former being 300° C. and that of the latter about 900° C.; but I find that on aspirating air over each salt and then over potassium iodide, the vapour from the lead chloride affects the potassium iodide much the sooner.

The difference in the speed of the two reactions (*a* and *c*) cannot therefore be caused by the difference in volatility.

(3) The degree of ionisation cannot be the cause of the difference noted, for mercuric chloride is known to be very slightly ionised in solution, while lead chloride may be taken as completely ionised.

(4) The specific reaction velocity appears to be the real determining factor, and the reaction is probably of the form $AB + CD = AD + BC$. If it is only free ions that react (which seems to me improbable), then the velocity of ionisation in the case of mercuric chloride must be extremely great.

There may also be other factors not yet understood.

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6. *Report of the Committee on the relation between the Absorption Spectra and Chemical Constitution of Organic Substances.*—See Reports, p. 126.

TUESDAY, SEPTEMBER 15.

The following Papers and Reports were read:—

1. *Freezing-point Curves for Binary Systems.*
By JAMES C. PHILIP, *M.A.*, *Ph.D.*

When a liquid mixture of two components is cooled, a point is reached at which separation of solid takes place. For complete interpretation of the phenomena, it is necessary to know not only (1) this temperature of initial freezing, but also (2) the composition of the separating solid, and (3) that of the liquid from which it separates. The varying character of the relation between (2) and (3) is best demonstrated graphically by plotting the one against the other in a square diagram. It is then found that the cases experimentally known fall into one or other of two classes, according as the composition of the solid varies continuously with that of the liquid, or is constant for certain ranges of concentration, and to that extent independent of the composition of the liquid. To the former class belong systems of two components that form mixed crystals; the components of systems in the latter class do not form mixed crystals, and the definite solids that separate out, each within its own range, are either the pure components or compounds of these. If consideration is confined to the latter class of cases, it is found that on the freezing-point curves (*i.e.* the curves obtained by plotting the temperature of initial freezing against the composition of the liquid) there is a branch corresponding with each range of concentration over which the separating solid is definite and constant. With the intersection of two branches on the freezing-point curve, there corresponds a vertical line on the square diagram, and where the freezing-point curve has an intermediate branch with a summit, there is

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on the square diagram a horizontal line cutting the diagonal. Further, the composition at a summit point on the freezing-point curve is exactly that of the definite solid separating out over that branch of the curve. Experimental examples of these relationships are supplied, for example, by Roozeboom's work on the hydrates of ferric chloride, Stortenbeker's work on iodine and chlorine, Heycock and Neville's work on gold and aluminium, and the author's work [1] on the freezing-point curves for mixtures of organic substances. Two cases are specially referred to: (*a*) where the freezing-point curve exhibits a branch that does not reach a summit; (*b*) where the two components form a compound that is dimorphous, and the corresponding freezing-point curve exhibits two intermediate branches, the one enveloping the other. Examples of case (*a*) are furnished by the freezing-point curve for gold and aluminium, and, to a certain extent, by that for phenol and urea.[2] Examples of case (*b*) are found in the freezing-point curve for iodine and chlorine, and in that for phenol and *p*-toluidine.[3]

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2. *A Contribution to the Constitution of Disaccharides.* *By* Thos. Purdie, *F.R.S.*, *and* James C. Irvine, *Ph.D.*, *D.Sc.*

It is shown in a recent communication to the Chemical Society that tetramethyl *a*-methyl glucoside, obtained by the action of methyl iodide and silver oxide on *a*-methyl glucoside, yields on hydrolysis a well-defined crystalline tetramethyl glucose possessing the ordinary properties of an aldose. The reactions of this substance prove that its unmethylated hydroxyl group is in the γ position, and direct evidence is thus obtained of the correctness of Fischer's formula for the parent methyl glucoside.

The authors have extended their experiments to the hydrolysable sugars, and the present paper deals with the results obtained in the methylation of cane-sugar and maltose.

Methylation of Cane-sugar.

An aqueous solution of cane-sugar was mixed with methyl alcohol and alkylated as usual by the addition of silver oxide and methyl iodide. The product, which was readily soluble in alcohol, was then treated as in the alkylation of methyl glucoside, two further alkylations in alcoholic solution and one in methyl iodide being necessary to complete the reaction.

The alkylated cane-sugar is a viscid neutral syrup readily soluble in ether, alcohol, or methyl iodide, and showing no action on Fehling's solution.

The compound has not yet been obtained in a state of purity, but combustions of the substance dried at 100° in a vacuum and methoxyl determinations by Zeisel's method showed that the alkylation was practically complete. On hydrolysis, which was effected by boiling with dilute hydrochloric acid, the initial dextro-rotation though not inverted was much reduced, and the cane-sugar ether was resolved into a mixture of methylated glucose and fructose. The former proved to be identical with the tetramethyl glucose (m.p. 81°–84°) above referred to; in one experiment the compound crystallised spontaneously from the oily product of the hydrolysis, whilst in other cases it was obtained only after fractional distillation of this product, being then found in the higher boiling distillate. The more volatile fractions, judging from their lower dextro-rotatory power, contained the methylated fructose, but the substance did not crystallise, and it was found impossible to effect a complete separation by vacuum distillation.

At our suggestion, Mr. D. M. Paul undertook the preparation of tetramethyl fructose from methyl fructoside, in the hope of establishing the identity of the substance with the methylated fructose produced in the above hydrolysis. The preparation yielded tetramethyl methyl fructoside as a colourless mobile oil boiling at 132°–136° under 10 mm. pressure and having no action on Fehling's solution.

[1] *Journal of the Chemical Society*, 1903, **83**, 814. [2] *Loc. cit.* [3] *Loc. cit.*

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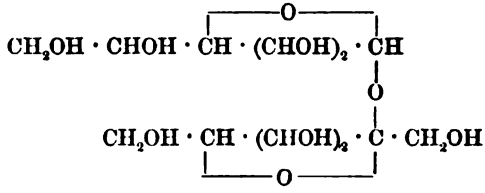
The hydrolysis of this compound gave a colourless liquid (b.p. 153°–156° under 13 mm. pressure), which readily reduced Fehling's solution and showed in approximately 5 per cent. alcoholic solution a specific rotation of −21·7°. The substance was evidently comparatively pure tetramethyl fructose. No crystalline derivative of the compound being obtained, we have thus so far no direct evidence of its production in the hydrolysis of alkylated cane-sugar.

The production from cane-sugar of the *identical* tetramethyl glucose previously obtained from methyl glucoside shows that the linking of the glucose residue in the former is the same as in the latter compound, and consequently Fischer's formula,[1]



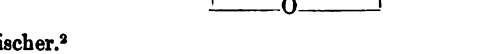
so far as the glucose half of the molecule is concerned, is proved to be correct.

Alkylation of Maltose.

The method adopted was similar to that already described for cane-sugar, save that no solvent water was required. The process was at first attended with an appreciable amount of oxidation, and after the first treatment the syrup obtained was acid in reaction. The final product was a thick neutral syrup without action on Fehling until hydrolysed. The assumption is that the free aldehyde group had been oxidised, and subsequently methylated. The substance was hydrolysed by boiling for an hour with 1½ per cent. hydrochloric acid. The solution was neutralised exactly with barium hydrate, evaporated in a vacuum at 60°, and the residue extracted with boiling alcohol. A mixture of the methylated glucose with the barium salt of the oxidation acid was thus obtained, from which the alkylated sugar was extracted with ether. From this extract tetramethyl glucose was obtained on distillation in a vacuum, and the substance, after removal of a trace of organic acid and some incompletely alkylated glucose, was finally obtained crystalline. After recrystallisation from ligroin the compound melted sharply at 84°, and its identity was further confirmed by analysis.

The acid produced by the oxidation was recovered from the barium salt. It distilled in a vacuum apparently without decomposition, and the figures obtained from combustions and methoxyl determinations agreed approximately with those required for tetramethyl gluconic acid.

The above results show that the linkage of the glucose residues in maltose is not of the acetal, but of the glucosidic type, and are in agreement with the formula



suggested by Fischer.[2]

The alkylation of polysaccharides and glucosides, and the identification of the alkylated products obtained by hydrolysis, seem to furnish a general method for elucidating the constitution of these compounds, and the authors are continuing their experiments in this direction.

[1] *Ber.* (1893), **26**, 2405. [2] *Loc. cit.*

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3. *Mutarotation in relation to the Lactonic Structure of Glucose.* *By* E. FRANKLAND ARMSTRONG, *Ph.D.*

Experiments have been made which show that the hydrolysis of β-methyl-glucoside by emulsin in its initial stages proceeds faster than the change of rotatory power of the glucose formed; it is accordingly possible to make optical determinations of the hydrolysis at given time intervals, and then by the addition of alkali stop the action of the enzyme, and at the same time rapidly convert the glucose into its stable form. On doing this a considerable rise in rotatory power was observed, proving that the β-glucoside yields on hydrolysis the modification of glucoside of low rotatory power corresponding to Tanret's solid γ-glucose. Similarly, α-glucosides yield the modification of high rotatory power corresponding to Tanret's solid α-glucose. These two compounds are thus lactones and differ only in respect of the groups attached to the terminal carbon atom. The manifestation of mutarotation is therefore dependent on the conversion of one or other lactone modification into a mixture of both in equilibrium, which, as the rotatory power of glucose is unaffected by small changes of temperature, is a constant at ordinary temperatures.

Glucose in solution is thus a mixture of two lactones; it is possible that the aldehydic form may also exist, but doubtful, as glucose does not show under ordinary conditions many of the milder aldehydic reactions. It has been possible to extend these results to other sugars—viz. galactose and maltose—with similar results.

From this point of view it is clear why, on the addition of hydrogen cyanide to glucose, two glucoheptose derivatives are formed in unequal quantities. It is no longer necessary to assume that the hydrogen cyanide combines selectively, as must be done if it be supposed that it is directly added to an aldehyde.

Horace Brown has suggested that there may possibly be a difference in the physiological behaviour of a sugar in its initial and final optical condition. In the case of the lactone formula, however, this is improbable, as the groups attached to terminal carbon atoms, which undergo rearrangement, are not concerned either in fermentation or enzyme action.

Thus, experiments made on the hydrolysis of milk sugar by lactase failed to reveal any change in the initial velocity of hydrolysis, whether a fresh solution or one which had been boiled and stood overnight was used.

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4. *Synthesis of Glucosides.* *By* W. SLOAN MILLS, *M.A.*

The first known instance of the synthesis of a glucoside occurring in nature was effected by Michael, who, having prepared helicin from acetochloroglucose and sodium salicylic aldehyde in absolute alcohol solution, reduced it with sodium amalgam and obtained salicin. Eugenol and phenol glucosides and also methyl-arbutin were prepared by Michael.[1] His method was somewhat modified by Ryan,[2] who prepared o- and p-cresol glucosides, and also carvacrol glucoside, which contains an unchanged phenolic hydroxyl group. Glucosides of the alcohols and mercaptans have been prepared by Fischer[3] by the action of the alcohol or mercaptan on the sugar in presence of hydrochloric acid. A series of crystalline α and β acetochloro- and acetobromo-glucoses have recently been obtained by Fischer and Armstrong,[4] by which the synthesis of many alkyl and phenol glucosides has been effected. They have also prepared acetodibromoglucose, which Professor Fischer allowed me to use with a view to preparing glucosides containing a bromine atom in the glucose rest, and also amidoglucosides.

[1] *Compt. Rend.* (1879), **89**, 355; and *Am. Chem. J.* 5, 6, 336.
[2] *J. C. S.* (1899) **75**, 1054.
[3] *Ber.* (1893) **26**, 2400; (1894) **27**, 674, 2483, 2985.
[4] *Ibid.* (1901) **34**, 2885.

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Preparation of Phenolbromoglucoside ($C_6H_7O.(OH)_3$ $Br.O.C_6H_5$).

A solution of potassium phenolate in absolute alcohol was allowed to act on a solution of acetodibromoglucose in chloroform for fourteen days. The solution was filtered, and the residue obtained on spontaneous evaporation was neutralised with acetic acid and extracted with ether. When the ether was evaporated a residue was obtained which, when recrystallised from dilute alcohol, gave beautiful white needle-shaped crystals of phenolbromoglucoside, melting at 165° C. The glucoside reduces Fehling's solution. It is easily soluble in ether, acetone, and ethyl acetate, soluble in alcohol, and somewhat soluble in chloroform. It is easily soluble in concentrated sodium hydroxide, and the solution, when carefully neutralised, gives a precipitate which melts at 170°–180° C., and which reduces Fehling's solution only after being hydrolysed by boiling with dilute acids. The bromine in phenolbromoglucoside is not precipitated by silver nitrate solution.

It is hoped to replace the bromine atom in this compound by an amido-group, and then by splitting off the phenol rest to obtain an amidoglucose, and thus determine the position of the second bromine atom in acetodibromoglucose.

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5. *Preparation of Oximido-compounds.* *By* W. Sloan Mills, *M.A.*

As it seemed desirable that the work described in the paper on 'The Action of Oxides of Nitrogen on Oximido-compounds' should be extended to other oximido compounds, *m*-nitrobenzalisonitrosoacetone and cuminalisonitrosoacetone and some of their derivatives were prepared.

Molecular proportions of isonitrosoacetone and *m*-nitrobenzaldehyde were condensed to *m*-nitrobenzalisonitrosoacetone ($C_6H_4{\cdot}NO_2{\cdot}CH=CH{\cdot}CO{\cdot}CH{:}NOH$) by means of sodium hydroxide. A theoretical yield was obtained. When recrystallised from absolute alcohol it gave slightly yellow coloured crystals, melting at 164° C., which were easily soluble in acetone, ether and glacial acetic acid. It was soluble in dilute sodium hydroxide. When treated with phenylhydrazine a yellow crystalline hydrazone was formed melting at 99°–100° C. When heated on a water-bath with excess of phenylhydrazine a dark-red insoluble precipitate was obtained, which melted at 206°–207° C., and proved to be the dihydrazone of *m*-nitrobenzalmethylglyoxal $\{C_6H_4(NO_2){\cdot}CH=CH{\cdot}C(:N{\cdot}NH{\cdot}C_6H_5){\cdot}CH(N{\cdot}NH{\cdot}C_6H_5)\}$.

m-Nitrobenzalisonitrosoacetoxime ($C_6H_4(NO_2){\cdot}CH=CH{\cdot}C=NOH{\cdot}CH=NOH$) was isolated when the ketone was treated with free hydroxylamine. It is soluble in glacial acetic acid, insoluble in absolute alcohol, and melts at 220° C. By the action of semicarbazide on the ketone *m*-nitrobenzalisonitrosoacetone semicarbazone $\{C_6H_4(NO_2){\cdot}CH=CH{\cdot}C(=N{\cdot}NH{\cdot}CO{\cdot}NH_2){\cdot}CH=NOH\}$ was obtained which melted at 196°–197° C.

Cuminalisonitrosoacetone $\{(CH_3)_2{\cdot}CH{\cdot}C_6H_4{\cdot}CH=CH{\cdot}CO{\cdot}CH=NOH)\}$ was prepared by the condensation of cuminol and isonitrosoacetone. It was recrystallised from benzene, giving beautiful sulphur yellow rectangular plates melting at 162°–163° C. It does not give readily a crystalline hydrazone. It is easily soluble in ether and acetone, soluble in benzene, and insoluble in petroleum ether. By the action of semicarbazide cuminalisonitrosoacetone semicarbazone $\{(CH_3)_2CH{\cdot}C_6H_4{\cdot}CH=CH{\cdot}C(N{\cdot}NH{\cdot}CO{\cdot}NH_2){\cdot}CH=NOH\}$ was obtained, which melted at 176° C. when recrystallised from dilute alcohol. It is easily soluble in acetone and soluble in ethyl acetate and ether. When the ketone was treated with free hydroxylamine in methyl-alcohol solution a beautiful white crystalline oxime $\{(CH_3)_2CH{\cdot}C_6H_4{\cdot}CH=CH{\cdot}C=NOH{\cdot}CH=NOH\}$ was precipitated on the addition of a little water. It melted at 192° C., and was easily soluble in ether acetone and ethyl acetate, soluble in alcohol and benzene, and somewhat soluble in chloroform.

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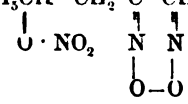
6. *The Action of Oxides of Nitrogen on Oximido-compounds.*

By W. SLOAN MILLS, *M.A.*

In connection with the study of the chemistry of indiarubber, in which Professor Harries, of the University of Berlin, is at present engaged, and which takes the form in the first place of an investigation into its behaviour towards oxides of nitrogen, I was intrusted with the simpler preparatory problem of investigating the action of oxides of nitrogen on oximido-compounds. For this purpose benzalisonitrosoacetone was prepared, which on being treated with free hydroxylamine under certain conditions in methyl-alcohol solution yielded long colourless prism-shaped crystals of benzalisonitrosoacetoxime ($C_6H_5CH=CH\cdot C=NOH\cdot CH=NOH$) melting at 201°-202° C. These were sparingly soluble in alcohol, chloroform, and acetone, soluble in glacial acetic acid, and insoluble in absolute ether. When the oxime was suspended in absolute ether, and treated at a low temperature with nitrogen peroxide, a light flocculent precipitate of the nitrate of benzalmethylglyoximehyperoxide



was formed, which melted when pure at 101°–102° C. It was insoluble in dilute sodium hydroxide and did not reduce Fehling's solution in the cold. When this substance was slightly heated in benzene solution, or in glacial acetic-acid solution, it was decomposed with the evolution of red fumes and the formation of benzalmethylglyoxalketoxime ($C_6H_5CH=CH\cdot C=NOH\cdot CHO$). When recrystallised from absolute alcohol, and subsequently from benzene, benzalmethylglyoxalketoxime separated in the form of slightly brown needle-shaped crystals melting at 103°–104° C. It was easily soluble in chloroform, acetone, benzene, and glacial acetic acid, and was soluble in ether. It reduced Fehling's solution in the cold and was soluble in dilute sodium hydroxide and in dilute nitric acid. When acted on by semicarbazide it yielded two isomeric semicarbazones, one of which was easily soluble in glacial acetic acid, and melted at 225°–226° C., and the other, which was insoluble in all the usual organic solvents, melted at 242° C.

Hence by preparing the oxime of benzalisonitrosoacetone, treating this with nitric peroxide and decomposing the resulting compound by heating it in benzene solution, the interesting transformation of benzalisonitrosoacetone ($C_6H_5CH=CH\cdot CO\cdot CH=NOH$) into the isomeric benzalmethylglyoxalketoxime ($C_6H_5CH=CH\cdot C=NOH\cdot CHO$) was accomplished.

When benzalisonitrosoacetone was dissolved in absolute ether and treated in a freezing mixture with nitrogen peroxide benzalisonitrosoacetone pseudonitrole ($C_6H_5CH=CH\cdot CO\cdot CHNO\cdot NO_2$) was formed. It was obtained crystalline from benzene in the form of yellow plates, melting at 123°–124° C., and was very soluble in most organic solvents. It gave Liebermann's nitroso-reaction, and did not reduce Fehling's solution in the cold.

Isonitrosoacetone semicarbazone ($CH_3\cdot C(=N\cdot NH\cdot CO\cdot NH_2)\cdot CH=NOH$) was prepared and gave white crystals, melting at 219°–220° C. It gave Liebermann's nitroso-reaction, and was insoluble in concentrated sodium hydroxide and soluble in dilute sodium hydroxide. When heated on a water-bath with acetic anhydride acetylisonitrosoacetone semicarbazone was obtained, which when recrystallised from glacial acetic acid gave cubic crystals melting at 186° C. It dissolved in dilute sodium hydroxide, and when reprecipitated with dilute sulphuric acid needle-shaped crystals melting at 218°–219° C. separated. Hence it was reconverted into the original semicarbazone by elimination of the acetyl group. When isonitrosoacetone semicarbazone was treated with nitrogen peroxide at a low temperature the pseudonitrole of isonitrosoacetone semicarbazone ($CH_3C(=N\cdot NH\cdot CO\cdot NH_2)\cdot CH=NO\cdot NO_2$) was formed. It melted at 163°–164° C. with sudden decomposition and gave Liebermann's nitroso- reaction. It

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was soluble in dilute sodium hydroxide, giving a yellow solution which was decomposed by dilute sulphuric acid with evolution of nitrogen and oxides of nitrogen.

When isonitrosoacetone ($CH_3CO \cdot CH = NOH$) in absolute-ether solution was acted on by nitrogen peroxide at a low temperature and the residue left on evaporation of the ether heated with benzene red fumes were evolved and diacetylglyoxime hyperoxide

$$\begin{array}{l} CH_3 \cdot CO \cdot C = NO \\ \qquad\qquad\quad | \quad | \\ CH_3CO \cdot C = NO \end{array}$$

was produced as a yellow oil. On treating this with phenylhydrazine the monohydrazone

$$\begin{array}{l} CH_3 \cdot C(=N \cdot NHC_6H_5) \cdot C = NO \\ \qquad\qquad\qquad\qquad\quad | \quad | \\ CH_3 \cdot CO \cdot C = NO \end{array}$$

was obtained in the form of yellow rhombic plates, melting at 161°–162° C. When the monohydrazone was heated with phenylhydrazine, or when the oil was treated with excess of phenylhydrazine, pale yellow rhombic plates of the dihydrazone

$$\begin{array}{l} CH_3 \cdot C(=N \cdot NH \cdot C_6H_5) \cdot C = NO \\ \qquad\qquad\qquad\qquad\quad | \quad | \\ CH_3C(=N \cdot NH \cdot C_6H_5) \cdot C = NO \end{array}$$

were formed, which melted at 176° C.

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7. *Further Investigation on the Approximate Estimation of Minute Quantities of Arsenic in Food.* *By* WILLIAM THOMSON, *F.I.C., F.R.S.E.*

The author finds the use of copper foil for wrapping around the portion of the tube to be heated (in the Marsh-Berzelius test), which modification was recommended by the Joint Committee of the Society of Chemical Industry and the Society of Public Analysts, to be disadvantageous, more distinct mirrors being obtained by heating the naked glass tube.

Although arseniuretted hydrogen is said to be decomposed at a temperature of 200° C., the author made experiments by heating the tube through which the gas from the Marsh-Berzelius apparatus was passing to 393° C., but got no trace of a mirror.

The best results were obtained by heating the tube to the highest temperature possible, and cooling the portion of the tube on which it was desired to deposit the mirror with a stream of cold water. This was best accomplished by folding over the thin part of the tube a single fold of tissue-paper to direct accurately the stream of water over the portion of the tube on which it is desired to deposit the arsenic. This point is most readily found by the aid of a long wire, thinner at one end than the other: the drawn-out portion of the tube is slightly conical, the thicker end of the wire is inserted, and at this point the tissue-paper is adjusted. The thinner end of the wire becomes arrested when pushed in about a quarter of an inch beyond the part at which the thicker end was arrested, so that the mirrors are all deposited on exactly the same internal diameter of tube. By this cooling process only one mirror is formed, leaving a brown metallic appearance. When the tube is not thus cooled two or more deposits of arsenic frequently take place, the first having a metallic appearance and the other being black.

It has been suggested that this behaviour is due to the presence of a trace of oxygen in the hydrogen; but it is probable that the black deposit is caused by the excessive amount of heat produced by the combustion of these two gases evaporating the brown metallic mirror, which at first forms and again becomes deposited as a black powder further on in the tube.

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If the metallic mirror be gently heated by waving the Bunsen flame over it in a current of hydrogen, it evaporates, and again deposits as a black powder. In this form it is not so easily compared with other deposits as the brown metallic form. These deposits, and more especially those in the form of black powder, fade when exposed to the light. The fading is most marked when the deposits are exposed in atmospheres of oxygen or nitrogen, and least in hydrogen and carbon dioxide.

The process as described (after destroying all organic matter with nitric and sulphuric acids) will show a distinct mirror with $\frac{1}{2000}$ of a grain per gallon, and the half of this can be distinctly detected.

The Marsh-Berzelius test is much more delicate than the electrolytic method recently devised by the Select Committee appointed by the Government. The platinum kathode will not give a mirror with a smaller amount than $\frac{1}{300}$ of a grain per gallon when working on 50 c.cs. of liquid; if a pure zinc kathode be used much greater delicacy can be attained, but even this is not equal in delicacy to the ordinary Marsh-Berzelius process.

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8. *Report of the Committee on the Study of Hydro-Aromatic Substances.* See Reports, p. 179.

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9. *Report of the Committee on Wave-length Tables of the Spectra of the Elements and Compounds.*—See Reports, p. 87.

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10. *Experiments and Observations with Radium Compounds.*

By WILLIAM ACKROYD, *F.I.C.*

The telluric distribution figure for radium is ·0003 when gold = 1.[1] The effects produced by rays from radium compounds simulate those of sensible heat in a very remarkable manner.

Phosphorescence.—Attention was early paid to diathermanous common salt, NaCl, under the influence of radium rays. This body was found to become in a few hours remarkably phosphorescent, and the phosphorescence lasts for hours after the removal of the exciting cause.[2] Slides of the photographic results are shown of—

1. A radium bromide tube alone containing 5 milligrams of the pure substance. Exposure, two minutes.
2. A radium bromide tube plus the sodium chloride in which it is imbedded. Exposure, two minutes.
3. Sodium chloride alone after action of radium rays. Exposure, thirty minutes.

The table salt experimented with was of slightly alkaline reaction to red litmus with traces of the usual impurities. The compound was therefore prepared (1) by precipitation from its solution with hydrochloric acid gas and (2) by the neutralisation of caustic soda solution with hydrochloric acid. In each case the sodium chloride became phosphorescent under the radium rays. The chloride with a trace of moisture in it gave better results than salt kept carefully dry in a desiccator after ignition. Salt moistened with hydrochloric acid solution, a little over normal strength, also exhibited phosphorescence.

Phipson in his 'Phosphorescence,' p. 20, says common salt is phosphorescent only at a temperature of about 200° C., and Sir D. Brewster observed phosphorescence when a solution of common salt was poured into a cup of heated iron.[3]

[1] *B.A. Report*, 1902, p. 581. [2] *Nature*, July 23, 1903.
[3] *Blackie's Pop. Ency.* xi. p. 49.

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Lithium chloride prepared from the carbonate, and then fused and ground up into a fine powder, exhibited phosphorescence; when, however, the trace of moisture present became excessive it ceased to phosphoresce.

Colour Change.—Sodium chloride is changed in a few hours to an orange or buff colour; the freshly ignited substance turns somewhat pinker in tint. Lithium chloride is not changed under the same circumstances. The absence of change in the lithium chloride and the change of colour of the sodium chloride, and also the order of the change in sodium chloride, are all colour facts of the same character as those which the author has grouped under the term 'metachromatism,' where inorganic bodies are changed in colour in the order of the metachromatic scale under the influence of sensible heat, and where the tendency to this change is least evident in the lightest members of a comparable group.[1] Bicarbonate of soda is changed to a light violet tint in twenty-four hours. This has direct bearing on the now well-known change of soda glass which was first observed by the Curies, but which the French observers usually attribute to the presence of a trace of manganese.

Emission of Heat.—An experiment has been devised in which the usual conditions of observation are reversed. A radium bromide tube is inclosed in a cylinder of filter paper which has been painted with one of Meusel's sensitive colour-changing salts. It was argued that in a medium of gradually rising temperature the heat from the radium compound within plus the heat from without would cause the transition colour change of the paper to be observed earlier in those parts in contact with the radium salt than in those not in contact. The result looked for was not observed. It was in several repetitions of this experiment that the fact was ascertained that a mixture of barium chloride and radium chloride placed in a moist atmosphere loses its remarkable properties of phosphorescing and of exciting phosphorescence in barium platinocyanide.[2] These facts appear to the author to be opposed to the doctrines of the electronists and to support the hypothesis that *one* of the sources of the energy of radium compounds is obscure heat coming from surrounding bodies.

[1] *Chem. News*, xxxiv. p. 76; *Phil. Mag.*, Dec. 1876; *Chem. News*, lxvii. pp. 27 and 64.

[2] Compare F. W. Branson, *Nature*, July 30, p. 302.

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SECTION C.—GEOLOGY.

PRESIDENT OF THE SECTION—Professor W. W. WATTS, M.Sc., SEC.G.S.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

THERE are two circumstances which invest the fact of my presidency of the Section this year with peculiar pleasure to myself. The first public lecture I ever gave was in the Town Hall at Birkdale in 1882, and the first of the fifteen meetings of the British Association which I have attended was that held in Southport in 1883.

There is still a third reason, that this meeting is in many respects a geological meeting. A palæobotanist is presiding over Section K, and the Council has invited, for the first time for many years, one geologist to deliver an evening discourse and another to give the address to artisans. I need hardly say that we are all looking forward to the lectures of Dr. Rowe and Dr. Flett with keen anticipation. To the one for his successful use of new methods of developing fossils and his scientific employment of the material thus prepared in stratigraphic research; to the other for his prompt, daring, and businesslike expedition to the scene of recent volcanic activity in the West Indies, during which he and his colleague, Dr. Tempest Anderson, collected so many important facts and brought away so much new knowledge of the mechanism of that disastrous and exceptional volcanic outbreak.

The Functions of Geology in Education and in Practical Life.

At the meeting in 1890, at Leeds, my old friend Professor A. H. Green delivered an address to the Section which has generally been regarded as expressing an opinion adverse to the use of the Science of Geology as an educational agent. Some of the expressions used by him, if taken alone, certainly seem to bear out this interpretation. For instance, he says: 'Geologists are in danger of becoming loose reasoners'; further he says: 'I cannot shut my eyes to the fact that when Geology is to be used as a means of education there are certain attendant risks that need to be carefully and watchfully guarded against.' Then he adds: 'Inferences based on such incomplete and shaky foundations must necessarily be largely hypothetical.'

Such expressions, falling from an accomplished mathematician and one who was such an eminent field geologist as Professor Green, the author of some of the most trustworthy and most useful of the Geological Survey Memoirs, and above all one of the clearest of our teachers and the writer of the best and most eminently practical text-book on Physical Geology in this or any other language, naturally exercised great influence on contemporary thought. And I should be as unwise as I am certainly rash in endeavouring to controvert them but for the fact that I think he only half believed his own words. He remarks that 'to be forewarned

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is a proverbial safeguard, and those who are alive to a danger will cast about for a means of guarding against it. And there are many ways of neutralising whatever there may be potentially harmful in the use of Geology for educational ends.'

After thus himself answering what is in reality his main indictment, Professor Green proceeds with the rest of an address crammed full of such valuable hints as could only fall from an experienced and practical teacher, showing how much could be done if the science were only properly taught.

And then he concludes by asking for 'that kindly and genial criticism with which the brotherhood of the hammer are wont to welcome attempts to strengthen the corner-stones and widen the domain of the science we love so well.'

I think the time has now come to speak with greater confidence; and, although the distance signal stands at danger, to forge ahead slowly but surely, keeping our eyes open for all the risks of the road, with one hand on the brakes and the other on the driving gear, secure at least in the confidence that Nature, unlike man, never switches a down train on to the up track.

Accessibility and Interest.

Those of us who have been teaching our science for any considerable time have come to realise that there are many reasons why Geology should be more widely taught than at present; that there are many types of mind to whom this science appeals as no other does; and that there are abundant places and frequent circumstances which allow of the teaching of it when other sciences are unsuitable.

To begin with, there is no science in which the materials for elementary teaching are so common, so cheap, and everywhere so accessible. Nor is there any science which touches so quickly the earliest and most elementary interests. It was for this reason that Huxley built his new science of Physiography on a geological basis. Hills, plains, valleys, crags, quarries, cuttings, are attractive to every boy and girl, and always rouse intelligent curiosity and frequent inquiry; and although the questions asked are difficult to answer in full, a keen teacher can soon set his children to hunt for fossils or structures which will give them part of the information they seek. Of course the teaching cannot go very far without simple laboratory and museum accommodation, and without a small expenditure on maps and sections; but the former of these requirements can soon be supplied from the chemical laboratory and by the collection of the students themselves, while the latter are every day becoming cheaper and more accessible and useful. The bicycle and the camera, too, are providing new teaching material and methods, while at the same time they are giving new interests. The bicycle has already begun to create a generation to whom relief maps are not an altogether sealed book, and for whom the laws which govern the relief of a country are rapidly finding practical utility; and the camera, at the same time that it quickens the appreciation of natural beauty, must give new interest to each scrap of knowledge as to the causes, whether botanical or geological, to which that beauty is due. And it is this new knowledge which in turn develops the æsthetic sense. *Mente, manu, et malleo* sums up most of what is required in the early stages of learning; but to round off the motto we still require words to express the camera and bicycle.

Field-work.

Another reason is the open-airness of the practice of the science. The delight of the open country comes with intense relief after the classroom, the laboratory, or the workshop. In education generally, and especially in geological education, we have reached the end of the period when

> 'all roads lead to Rome
> Or books—the refuge of the destitute.'

Of course I realise fully the vital necessity of laboratory and museum work in the stages of both learning and investigation, and quite freely admit that there is an

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immense amount of useful work being done and to be done in these institutions alone. But what I think I do right to insist upon is that all work in the laboratory and museum must be mainly preparatory to the field-work which is to follow; every type of geological student must be sent into the field sooner or later, and in most cases the sooner the better. I have generally found that students in the early stages have a great repugnance to the grind of working through countless varieties of minerals, rocks, and fossils; but once they have gone into the field, collected with their own hands, and seen the importance of these things, and the inferences to be drawn from them, for themselves—once indeed they have got keen—they come back willingly, even eagerly, to any amount of hard indoor work.

But it is when they leave ordinary excursion work and start upon regular field training that one really feels them spurt forward. As soon as they begin to realise that surface-features are only the reflex of rock-structure and can be utilised for mapping, that to check their lines and initiate new ones they must search for and find new exposures, and that each observation while settling perhaps one disputed point may originate a host of new ones, when above all they can be trusted with a certain amount of individual responsibility and given a definite point to settle for themselves, it is then that their progress is most rapid, and is bounded only by their powers of endurance.

I have often watched my students through the various stages of their field training with the deepest interest as a study of the development of character. At first they look upon it merely as a relief from the tedium of the classroom and laboratory, and as a pleasant country excursion. But gradually the fascination of research comes over them, and as they feel their capacity increasing and their grip and insight into the structure of the country deepening, one can see them growing up under one's eyes. They come into the field a rabble of larky boys; they begin to develop into men before they leave it.

And what is true of students is more than ever true of the working geologist. I hold that every geologist, whatever his special branch may be, should spend a portion of every year in the field. Though a petrologist may have specimens sent to him from every variety, even the common ones, in a rock mass, and have their relations and proportions properly explained to him, it is quite impossible for him to feel and appreciate these proportions and relationships so well as if he had studied and collected in the field and gained a personal interest in them. Besides this the conclusions drawn in the field are the crystalline and washed residuum, so to speak, left on the mind after the handling of dozens of specimens, weathered and unweathered, and the seeing them in a host of different lights and aspects. The rock is hammered and puzzled over and its relations studied until some conclusion is arrived at which bears the test of application to all the facts observed in the field.

Again, once a palæontologist is divorced from the field he loses the significance of minute time variations, the proportion of aberrant to normal forms, and the value of naked-eye characteristics which can be 'spotted' in the field. Huxley once asked for a palæontologist who was no geologist; I venture to think we have now had enough of them. What we want above all at the present time is the recognition of such characters as have enabled our field palæontologists to zone by means of the graptolites, the ammonites, and the echinids, so that every rock system we possess may be subdivided with the same minuteness and exactitude as the Ordovician, Silurian, and Jurassic systems, and the Chalk.

If this is once done the biological results will take care of themselves, and we may feel perfect confidence that new laws of biological succession and evolution will result from such work, as indeed they are now doing—laws which could never be reached from first principles, but could only come out in the hands of those to whom time and place were the factors by which they were most impressed. It is only by field work that we shall ever get rid of the confusion which has been inevitable from the supposed existence of such so-called species as *Orthis caligramma*, *Atrypa reticularis*, and *Productus giganteus*.

As for the geological results, it is only necessary to read the excellent and workmanlike Address delivered to this Section at Liverpool in 1896 by Mr. Marr

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to realise how many problems of succession and structure, of distribution and causation, of ancient geography and modern landscape, are still awaiting solution by the application of minute and exact zonal researches.

On the other hand it goes without saying that the more a field geologist knows of his rocks and fossils the better will his stratigraphical work become; but this is too obvious to require more than stating.

Recreation.

Geology, again, is of value as a recreative science, one which can be enjoyed when cycling, walking, or climbing, even when sailing or travelling by rail. Indeed it is difficult to find a place in which to treat the confirmed geologist if you wish to make him a 'total abstainer.' There are others than those who must make use of their science in their professions; those in need of a hobby, those interested in natural scenery, veterans who have seen much and now have leisure and means to see more, and those fortunate ones who have not to earn their bread by the sweat of their brain or brow. Many of these have done and are doing good work for us, and many more would find real pleasure in doing so if only they had been inoculated in those early days when impressions sink deep. Mr. A. S. Reid, who has had much and fruitful experience in teaching, tells me that he has often seen seed planted in barren ground at school spring up and grow and blossom as a country-holiday recreation after schooldays, or bear the good fruit of solid research after lying dormant for many years.

Observation.

We may next look upon Geology as an educational medium from quite a different point of view. If more than half the work of the man of science is the collection of fact, and of actual fact as opposed to the result of the personal equation, Geology is perhaps the very best training-ground. There are such hosts of facts to be still recorded, so many erroneous observations to be corrected, and so much hope of extending observations on already recorded facts, that there is plenty of work even for the man who can snatch but limited leisure from other pursuits and the one who is a collector of fact and nothing else, as well as those

> 'under whose command
> 'Is Earth and Earth's, and in their hand
> 'Is Nature like an open book.'

But in the collection of facts a wise and careful selection is constantly necessary in order to pick out from the multitude those which are of exceptional value and importance in the construction of hypotheses. Nature, it is true, cannot lie; but she is an expert witness, and it takes an astonishing amount of acute cross-examination to elicit the truth, the whole truth, and nothing but the truth.

There is no science which needs such a variety of observations as Field Geology. When we remember that Sedgwick and Darwin visited Cwm Glas and carried away no recollection of the features which now shout 'glaciation' to everyone who enters the Cwm, it is easy to see how alert must be the eyes and how agile the mind of the man who has to carry a dozen problems in his mind at once, and must be on the look-out for evidence with regard to all of them if he would work out the structure of a difficult country; and who is not only looking out for facts to test his own hypothesis, but wishes to observe so accurately that if his hypothesis gives way even at the eleventh hour his facts are ready to suggest and test its successor. There is no class of men so well up in what may be called observational natural history generally as the practised field geologist, because he never knows at what moment some chance observation—a mound, a spring, a flower, a feature, even a rabbit-hole or a shadow—may be of service to him. Not only should he know his country in its every feature and every aspect, but he must have, and in most cases soon acquires, that remarkable instinct, which can only be denoted as an 'eye for a country,' with which generally goes a naturalist's knowledge of its plants and of its birds, beasts, and fishes.

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Experiment.

At the present time many educationists are in favour of teaching only the experimental sciences to the exclusion of those which collect their facts by observation. This attitude may do some good to Geology in compelling us to pay more attention to that side of our science which has been better cultivated hitherto in France than in our own country. But whether we think of education as the equipping of a scientific man for his future career or as the training of the mind to encounter the problems of life, we must admit that it would be as wrong to ignore one of the only two ways of collecting fact as it would be to teach deductive reasoning to the exclusion of that by induction. Indeed this is understating the case, for in the vast majority of the problems which confront us in everyday life the solution can only be reached if an accurate grasp of the facts can be obtained from observation. The training of the mind solely by means of experiments carefully designed to eliminate all confusing and collateral elements savours too much of 'milk for babes' and too little of 'strong meat for men.'

Theory.

Mr. Teall in his masterly Address to the Geological Society in 1901 pointed out 'that the state of advancement of a science must be measured, not by the number of facts collected, but by the number of facts *coordinated*.' Theory, consistent, comprehensive, tested, verified, is the life-blood of our science as of every other. It is what history is to politics, what morals are to manners, and what faith is to religion.

It is almost impossible to collect facts at all without carrying a working hypothesis to string them on. It is easy to follow Darwin's advice and speculate freely; the speculation may be right, and if wrong it will be weeded out by new facts and criticism, while the speculative instinct will suggest others. In hypothesis there will always be an ultimate survival of the fittest.

And it is not only easy but absolutely necessary, because in Geology, more perhaps than in any other science, hypotheses are like steps in a staircase: each one must be mounted before the next one can be reached; and if you have no intention of coming back again that way, it does not matter if you destroy each step when you have made use of it. Every new hypothesis has something fresh to teach, and nearly all have some element of untruth to be ultimately eliminated. But each one is a stage, and a necessary stage, in progress.

In physics and in chemistry the chief difficulties are those which surround the making of experiments. When these have been successfully overcome the right theory follows naturally, and verification is not usually a very lengthy process. In Geology, on the other hand, theory is more quickly arrived at from the numerous facts; but the price is paid in the patience required for testing and the ruthless refusal to strain fact to fit theory. Every hypothesis leads back to facts again and again for verification, extension, and improvement.

Principles.

Many of the leading conclusions of our science have not yet become part of the common stock of the knowledge of the world; indeed they are not even fully realised by many men eminent in their own sciences. The momentum given by Werner and Playfair, Phillips and Jukes, Sedgwick, Darwin, and Lyell, and other pioneers of the fighting science, has died down, and in the interval of hard work, detailed observation, minute subdivision, involved classification, and pedantic nomenclature which has followed, and which I believe to be only the prelude to an epoch of more important generalisation in the immediate future, it has been difficult for an outsider to see the wood for the trees. He has hardly yet realised that facts as vital to the social and economic well-being of the people at large, and conclusions of as great importance in the progress of the science and of as far-reaching consequence in the allied sciences, are being wrung from Nature now as in the past.

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'The unimaginable touch of Time,' the antiquity of the globe as the abode of life, the absolute proof of the evolution of life given by fossils, the evidence of change and evolution in geography and climate, the antiquity of man, the nature of the earth's interior, the tremendous cumulative effect of small causes, the definite position of deposits of economic value, the rôle played by denudation and earth-movement in the development of landscape, the view of the earth as a living organism with the heyday of its youth, its maturity, and its future old age and death, to mention but a few of our great principles, furnish us with conceptions which cannot fail to quicken the attention and inspire the thought of students of history, geography, and other sciences.

Now that these things are capable of definite proof, that they are of real significance in the cognate sciences and of actual economic value, above all now that the nineteenth century, the geological century, has closed, that the heroic age is over, that we have passed the stages of scepticism and religious intolerance, and reached the stage 'when everybody knew it before,' it might be expected that a fairly accurate knowledge and appreciation of these principles should form part of the common stock of knowledge, and be a starting-point in the teaching of allied sciences.

Topography.

Another feature which adds to the attractiveness of geological observations is their immediate usefulness from many points of view. The relief and outline of any area is as closely related to its rocky framework as the form of a human being is related to his skeleton and muscles. The geological surveyor recognises how every rise and fall is the direct reflex of some corresponding difference in the underlying rocks; he seeks to observe and explain the ordinary as well as anomalous ground-features, every one of which conveys some meaning to him.

A geological basis for the classification and grouping of surface-features is the only one which is likely to be satisfactory in the end, because it is the only one founded on a definite natural principle, the relation of cause to effect. It is not without good reason that the topographic and geological surveys of the United States are combined under one management, and nowhere else are the topographic results more accurate and satisfactory. Landscape is traced back to its ultimate source, and consequently sketched in with more feeling for the country and greater accuracy of knowledge than would otherwise be possible. Geologists were among the first to cry out for increasing accuracy and detail in our government maps, and they have consistently made the utmost use of the best of these maps as fast as they appeared. With the publication of each type of map, hachured, contoured, six-inch, twenty-five inch, the value and accuracy of geological mapping has advanced step by step. Wherever the topography is better delineated than usual, the facilities are greater for accurate geological work, and the best geological maps, and those in greatest demand, are always those based on the most minute and detailed topographic work. On the other hand geologists are training up a class of men who can read and interpret the inner meaning of these maps, and make the fullest use of the splendid facilities given by the minute accuracy of the ordnance work.

Lord Roberts has recently complained that the cadets at Woolwich are unable to read and interpret maps, and he 'strongly advised them to set about improving themselves in this respect, or they would find themselves heavily handicapped in the future.' In his evidence before the War Commission he has emphasised the same disability among staff officers. I believe that the only training in this subject before entering the Royal Military Academy and the Royal Military College has been that given to those candidates who have taken up Geology for their entrance examination. By encouraging these students to study and draw maps and sections of their own districts, and to explain and draw sections across geological maps generally, thus accounting for surface-features, the examiners have compelled this small group of candidates to see deeper into a map than ordinary people. If only this training had been encouraged and advanced and made use of later, the Com-

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mander-in-Chief would have had no cause of complaint with regard to these particular men. Looking at a map is one thing; working at it, seeing into it, and getting out of it what is wanted from the vast mass of information crammed into it, is quite another; and Geology is the very best and perhaps the only means of compelling such a close study of maps as to enable students to seize upon the salient features of a country from a map as quickly and accurately as if the country itself were spread out before them. The geologist is compelled to work out and classify for himself the features he observes on his maps, such as scarps and terraces, crags and waterfalls, streams and gorges, passes and ridges, the run of the roads, canals, and railways, the nature and accessibility of the coast, and all those features which make the difference between easy-going and a difficult country. When he has worked his way over a map in this fashion that map becomes to him a real and telling picture of the country itself.

Experience, bitter experience, in South Africa has shown the necessity not only for good maps and map-reading, but for that which is the most priceless possession alike of the best stratigraphers and of the best strategists, a good 'eye for a country.' It has been said that the Boer war was a geographical war; but it was even more, and, especially in its later stages, a topographic war. Again and again the Boers aroused our astonishment and admiration by the way in which their topographic knowledge and instinct enabled them to fight, to defend themselves, and to secure their retreat, by the most consummate ability in utilising the natural features of their country. This was due to two things. In the first place they took care to have with them in each part of the country the men who knew that particular district best in every detail and in every aspect. But in the second place there can be no doubt that they made the utmost use of that hunter-craft by which the majority of them could take in at a glance the character of a country, even a new one, as a whole, guided by certain unconscious principles which each man absorbed as part of his country life and hunter's training. They possessed, and had of necessity cultivated to a very high degree, an 'eye for a country.'

Now the study of the geology of any district, and especially the geological mapping of it, goes a long way towards giving and educating the very kind of eye for a country which is required, partly by reason of the practice in observation and interpretation which it is continuously giving, and partly because it deliberately supplies the very kinds of classification and the principles of form which a hunter-people have unconsciously built up from their outdoor experience.

Any geologist who thinks of the Weald, the wolds and downs of Eastern England, the scarps and terraces of the Pennine, the buried mountain structure of the Midlands, even the complicated mountain types of Lakeland and Wales, will remember how often his general knowledge of the rock-structure of the region has helped him as a guide to the topography; and as his geological knowledge of the area has increased he will recall how easy it has become to carry the most complicated topography in his mind, or to revive his recollection of it from a glance at the map, because the geological structure, the anatomy, is present in his mind throughout, and the outside form is the inevitable consequence of that structure. Indeed the reading of a good geological map to the geologist is like the reading of score to a musician.

Surely it would be most unwise if the Committee on Military Education were to cut out of their curriculum the only subject which has exercised and educated this faculty, and one which is at the same time doing a great deal to counteract that degeneration of observing faculties inseparable from a town life. Some cadets at least ought to be chosen from amongst those men who have been trained by this method to see quickly and accurately into the topographic character and possibilities of a country, and provision should be made for educating their faculties further until they become of genuine strategic value.

Then I believe it would be correct to say that no class of men get to know their own district with anything like the minuteness and accuracy of the geological surveyor. The mere topographer simply transfers his impressions on the spot as quickly as may be to paper, and has no further concern with them. The geologist must keep them stored in his mind, watching the variation and development of

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each feature from point to point for his own purposes. He must traverse every inch of his ground, he must know where he can climb each mountain and ford every brook, where there are quarries or roads, springs or flats; what can be seen from every point of view, how the habitability or habitations vary from point to point; in short, he must become a veritable walking map of his own district. Why not scatter such men in every quarter of the globe, particularly where any trouble is likely to arise? They are cheap enough, they will waste no time, and they will be so glad of the chance for research that they will not be hard to satisfy in the matter of pay and equipment. Thus you will acquire a corps of guides, ready wherever and whenever they are wanted; and when trouble arises they may do a great deal by means of their minute knowledge of topography to save millions of money and thousands of lives, and to prevent the irritating recurrence of the kind of disaster with which we have become sadly familiar within the last five years.

Geography.

In dealing with the relationship of Geology to Geography geologists are frequently charged with claiming too much. On this point at least, however, there can be no difference of opinion, that the majority of geological surveyors and unofficial investigators have kept their eyes open to this relationship, and have often contributed new explanations of old problems. They have been compelled to observe, and often to explain, surface-features before making use of them in their own mapping, and in doing so have often hit upon new principles. It is hardly needful to mention such examples as Ramsay's great conception of plains of marine denudation, Whitaker's convincing memoir on sub-aërial denudation, Jukes's explanation of the laws of river adjustment, Gilbert's scientific essay on erosion, Heim's demonstration of the share taken by earth-movement in the modelling of landscape features, and the exceedingly valuable proofs of the relation of human settlement and movement to underground structure, worked out with such skill and diligence by Topley in his masterly memoir on the Weald—the jumping-off place, if I may so term it, of the new geography.

No one is more pleased than geologists that geographers have ceased to draw their knowledge of causation solely from history, and that they have turned their attention to the dependence and reaction of mankind on nature as well. But while hoping that geographers will continue to study, so far as they logically can, the relationship of plants, animals, and mankind to the solid framework of the globe on which they live, we must draw the line at the invention of new geological hypotheses to explain geographic difficulties on no better evidence than that furnished by the difficulties themselves; on the other hand, we must insist that each new geological principle must take its place among geographic explanations as soon as it is freely admitted to be based on a sound substratum of fact.

I must confine myself to a few instances of what I mean. Mr. Marr's geological work on the origin of lake-basins has led to some remarkable and unexpected conclusions with regard to the history and origin of the drainage of the Lake district. Some of the very difficult questions raised by the physical geography of the North Riding of Yorkshire have received a new explanation from the researches of Professor Kendall and Mr. Dwerryhouse, an explanation which is the outcome of purely geological methods of observation of geological materials. Again, the simple geological interpretation of a well-known unconformity between Archæan and Triassic rocks has made it extremely probable that many of the present landscapes, not only in the Midlands but elsewhere, may be really fossil landscapes, of great antiquity and due to causes quite different from those in operation there at the present day. In mountain regions, too, it can only be by geological observation that we shall ever determine what has been the precise direct share of earth-movement in the production of surface relief. Such examples seem to indicate that many of the principles must be of geological origin but of geographic application.

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Economics.

While Geology has been of direct scientific utility in topography and geography there is another domain, that of Economic Geology, which is entirely its own. The application of Geology extends to every industry and occupation which has to do with our connexion with the earth on which we live. Agriculture, engineering, the obtaining of the useful and precious metals, chemical substances, building materials, and road metals, sanitary science, the winning and working of coal, iron, oil, gas, and water, all these and many more pursuits are carried on the better if founded on a knowledge of the structure of the earth's crust. Indeed a geological map of this country, showing rocks, solid and superficial, of which no economic use could be made, would be nearly blank. Yet so much has this side of the science been neglected of recent years that our only comprehensive text-books on it are altogether out of date.

But in teaching Geology as a technical science, or rather as one with technological applications, one of the greatest difficulties before us is to steer between two opposing schools, the so-called theoretical school and the practical school.

There are those who say that there is but one geology, the theoretical, and that a thorough knowledge of this must be obtained by all those who intend to apply the science. Others think that this is too much to ask—that the time available is not sufficient—and that it is only necessary to teach so much of the subject as is obviously germane to the question in hand.

The best course appears to me to be the middle one between the two extremes. If the engineer or miner, the water-finder or quarryman, has no knowledge of principles, but only of such facts as appear to be required in the present position of his profession, he will be incapable of making any improvement in his methods so far as they depend upon geology. If, on the other hand, he is a purely theoretical man without a detailed practical and working acquaintance with the facts which specially concern him, he will be put down by his colleagues as unpractical; he will have to learn the facts as quickly as he can and buy his experience in the dearest market.

It seems to me that there is certain common ground which must be acquired by all types of professional men. The general petrographic character of the common rocks, enough of their mode of origin to aid the memory, the principle of order and age in the stratified rocks, the use of fossils and superposition as tests of age, the nature of unconformities, the relation of structure to the form of the ground, the occurrence of folds and faults, and above all the reading of maps and sections, and sufficient field work to give confidence in the representation of facts on maps—these things are required by everybody who makes any use of geology in his daily life.

But when so much has been acquired it should be possible to separate out the students for more special treatment. The coal-miner will require especially a full knowledge of the coal-bearing systems, not in our own islands merely, but all over the world; a special acquaintance with the effects of folds and faults, and an advanced training in the maps and sections of coal-bearing areas. The vein-miner should be well up in faulting and all the geometrical problems associated with it, and he should have an exhaustive acquaintance with the vein and metalliferous minerals.

The water engineer needs to know especially well the porous and impervious rock types, the texture and composition of these rocks, the nature of their cements and joints, and the distribution of water levels in them. Further, he must know what there is to be known on the problems of permeability and absorption, the relation of rain to supply, the changes undergone by water and the paths taken by it on its route underground, and the varying nature of rocks in depth. He must also understand the effects of folds and faults on drainage areas and on underground watercourses, the special qualities of water-yielding rocks, of those forming the foundation of reservoir sites, and those suitable for the construction of dams.

The sanitary engineer will need to be acquainted with the same range of

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special knowledge as the water engineer, but will naturally be more interested in getting rid of surface water without contaminating it more than he can help than in obtaining it; he will also need a more detailed acquaintance with superficial deposits than any other class of professional men.

The quarryman and architect ought to know the rocks both macroscopically and microscopically, in their chemical and mineralogical character, their grains and their cements. But he ought to be well acquainted with the laws of bedding, jointing, and cleavage, with questions of outcrop and underground extent, and all those other characters which make the difference between good and bad stone, or between one desirable and undesirable in the particular circumstances in which a building is to be erected. Further, he should make a particular study of the action of weight and weather on the rocks which he employs.

The road engineer and surveyor, now that it has been discovered that it is cheaper and better to use the best and most lasting road-metal instead of any that happens to be at hand, requires to have an extensive acquaintance with our igneous and other durable rocks. He needs, however, not only petrographic and chemical knowledge, but also a type of information not at present accessible in England, the relative value of these rocks in resisting the wear and tear of traffic, the cementing power of the worn material, and the surface characters of roads made from them, in order that he may in each case select the stone which in his particular circumstances gives the best value for money. It would surely pay the county councils to follow, with modifications, the example of the French and Americans, and carry out a deliberate and well-planned series of experiments on all the material accessible to them in their respective districts.

The teaching of the application of Geology should therefore take some such form as the following:—First, the principles should be thoroughly taught with the use for the most part of examples drawn from the economic side; thus cementing might be illustrated on the side of water percolation, jointing from the making of mine roads and from quarry sites, faulting from effects on coal outcrops and veins, unconformity from its significance to the coal-miner; while in teaching the sequence of stratified rocks the systems and stages could be mainly individualised by their economic characters. When this has been done the class must be divided into groups, each paying special attention to the points which are of essential importance to it.

The teaching at all stages should be practical and, so far as can be, experimental, and in all cases where possible a certain amount of field work should be attempted. For the field after all is the laboratory of the geologist, where he can observe experiments being made on a gigantic scale under his eyes.

The aim of the teaching should be to give to students the equipment necessary to deal with the chief geological problems that they will meet with in their varied professions; it should show them where to go for maps, memoirs, or descriptions of the areas with which they are dealing; and in cases of great difficulty should enable them to see where further geological assistance is required, and to weigh and balance the expert evidence given them against the economic and other factors of the problem before them.

From men educated thus Geology has the right to expect a valuable return. There is a vast amount of knowledge on economic subjects in existence but not readily accessible. It has been obtained by experts, and after being used is locked up or lost. And yet it is the very kind of knowledge which is wanted to extend our principles further into the economic side of the subject. So well is this recognised that many geologists are attracted to economic work mainly because of the wide range of new facts that they can only thus become acquainted with. It is possible to make use of many of these facts for scientific induction without in any way betraying confidence or revealing the source from which they are obtained; and even if they cannot be used directly they are often of great service in giving moral support, or the contrary, to working hypotheses founded on other evidence.

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Resources.

The knowledge of our mineral resources is of such vital consequence to ourselves and to our present and future welfare as a nation, and yet it is a matter of so much popular misconception, that I feel bound to dwell on this subject a little longer. To anyone who studies the growth and distribution of population in any important modern State the facts and reasons become as clear as day.

It is easy to construct maps showing at a glance the density of population in any country. Perhaps the most effective way to do so is to draw a series of isodemic lines and to gradually increase the depth of tint within them as the number of people per square mile increases until absolute blackness represents, say, over 2,000 people per square mile. Such maps are the best means of displaying the geography of the available sources of energy in a country at any particular period. Population maps of England and Wales in the early part of the eighteenth century would be pale in tint with a few rather darker patches, and would show a distribution dependent solely upon *food* as a source of energy working through the medium of mankind and animals. Such maps would be purely agricultural and maricultural, dependent upon the harvests of the land and sea. Maps made at a later period would show a new concentration round other sources of energy, particularly wind and water, but would not be perceptibly darker in tint as a whole; for although we are apt to think that we have in this country too much wind and water, they are not in such a form that we can extract any appreciable supply of energy directly from them.

But maps representing the present population, while still mainly energy maps, at once bring out the fact that our leading source of energy is now *coal* and no longer food, wind, or water. The new concentrations, marked now by patches and bands of deepest black, have shifted away from the agricultural regions and settled upon and around the coalfields. The map has now become geological.

The difference between the old and the new map is, however, not only in kind; it is even more remarkable in degree. The population is everywhere much denser. Not only are the mining and manufacturing areas on the new map more than eight times as densely populated as any areas on the older map, not only is the average population five times greater throughout the country, but the lightest spot on the new map is nearly as dark as the darkest spot on the old one. The sparsest population at the present day is as thick on the ground as it was in the densest spots indicated on the older map, while at the same time the standards of wages, living, and comfort, instead of falling, have risen.

The discovery of this new source of energy, coal, immediately gave employment to a much larger number of people; it paid for their food and provided the means of transporting it from the uttermost parts of the earth. Under agricultural conditions the map shows that the population attained a given maximum density, and no further increase was possible, the density being regulated by the food supply raised on the surface of the land. Our dwelling-house was but *one* story high. Under industrial conditions our mineral resources can support five times the number. Our dwelling-house is of *five* stories—one above ground and four below it.

At the same time the type of distribution is altered. The agricultural areas are now covered by a relatively scanty population, and the dense areas are situated on or near to the coal and iron fields, the regions yielding other metals, those suitable for industries which consume large supplies of fuel, and a host of new distributing centres, nodal points on the new lines of traffic, either inside the country or on its margins where the great routes of ocean transport converge, or where the sea penetrates far in towards the industrial regions.

It has been the good fortune of this country to be the first to realise, and with characteristic energy to take advantage of, the new possibilities for development opened up by the discovery and utilisation of its mineral wealth. We were exceedingly fortunate in having so much of this wealth at hand, easy to get and work from geological considerations, cheap to transport and export from geographical considerations. So we were able to pay cash for the products of the whole

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world, to handle, manufacture, and transport them, and thus to become the traders and carriers of the world.

But other nations are waking up. We have no monopoly of underground wealth, and day by day we are feeling the competition of their awakening strength. Can we carry on the struggle and maintain the lead we have gained?

In answering this question there are three great considerations to keep in mind. First, our own mineral wealth is not exhausted; secondly, that of our colonies is as yet almost untouched; and thirdly, there are still many uncolonised areas left in the world.

The very plenty of our coal and iron, and the ease of extracting it, has been an economic danger. There has been waste in exploration because of ignorance of the structure and position of the coal-yielding rocks; waste in extraction because of defective appliances, of the working only of the best-paying seams and areas, of the water difficulty, and the want of well-kept plans and records of areas worked and unworked; waste in employment because of the low efficiency of the machinery which turns this energy into work. With all this waste our coalfields have hardly yielded a miserable *one per cent.* of the energy which the coal actually possesses when *in situ*.

Engineers and miners are trying to diminish two of these sources of waste, and Geology has done something to reduce that of exploration. This has been done by detailed mapping and study, so that we now know the areas covered by the coal-seams, their varying thickness, the 'wants,' folds, and faults by which they are traversed, and all that great group of characters designated as the geological structure of the coalfields. It could not have been accomplished unless unproductive as well as productive areas had been studied, the margins of the fields mapped as well as their interiors, and unless the geological principles wrested from all sorts of rocks and regions had been available for application to the coal districts in question. We no longer imagine every grey shale to be an index of coal; we are not frightened by every roll or fault we meet with underground; nor do we, as in the past, throw away vast sums of money in sinking for coal in Cambrian or Silurian rocks.

We cannot afford, hard bitten as we are in the rough school of experience and with our increased knowledge, to make all the old mistakes over again, and yet we are on the very eve of doing it. Up to the present it is our visible coalfields that we have been working, and we have got to know their extent and character fairly well. But so much coal has now been raised, so much wasted in extraction, and so many areas rendered dangerous or impossible to work, that we cannot shut our eyes to the grave fact that these visible fields are rapidly approaching exhaustion. The Government have done well to take stock again of our coal supply and to make a really serious attempt by means of a Royal Commission to gauge its extent and duration; and we all look forward to that Commission to direct attention to this serious waste and to the possibility of better economy which will result from the fuller application of scientific method to exploration, working, and employment.

But we still have an area of concealed coalfields left, possibly at least as large and productive as those already explored and as full of hope for increased industrial development. It is to these we must now turn attention with a view of obtaining from them the maximum amount possible of the energy that they contain. The same problems which beset the earlier explorers of the visible coalfields will again be present with us in our new task, and there will be in addition a host of new ones, even more difficult and costly to solve. In spite of this the task will have to be undertaken, and we must not rest until we have as good a knowledge of the concealed coalfields as we have of those at the surface. This knowledge will have to be obtained in the old way by geological surveying and mapping and by the coordination of all the observations available in the productive rocks themselves and in those associated with them, whether made in the course of geological study or in mining and exploration. But now the work will have to be done at a depth of thousands instead of hundreds of feet, and under a thick cover of newer strata resting unconformably on those we wish to pierce and

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work. When we get under the unconformable cover we meet the same geology and the same laws of stratigraphy and structure as in more superficial deposits, but accurate induction is rendered increasingly difficult by the paucity of exposures and the small number of facts available owing to the great expense of deep boring. How precious, then, becomes every scrap of information obtained from sinkings and borings, not only where success is met with, but where it is not; and how little short of criminal is it that there should be the probability that much of this information is being and will be irretrievably lost!

Mr. Harmer pointed out in a paper to this Section in 1895 that under present conditions there was an automatic check on all explorations of this kind. The only person who can carry it out is the landowner. If he fails he loses his money and does not even secure the sympathy of his neighbours. If he succeeds his neighbours stand to gain as much as he does without sharing in the expense. The successful explorer naturally conceals the information he has acquired because he has had to pay so heavily for it that he cannot afford to put his neighbours in as good a position as himself and make them his rivals as well; while the unsuccessful man is only too glad to forget as soon as possible all about his unfortunate venture. And yet in work of this kind failure is second only to success in the value of the information it gives as to the underground structure which it is so necessary to have if deep mining is to become a real addition to the resources of the country.

Systematic and detailed exploration, guided by scientific principles and advancing from the known to the unknown, ought to be our next move forward: a method of exploration which shall benefit the nation as well as the individual, a careful record of everything done, a body of men who shall interpret and map the facts as they are acquired and draw conclusions with regard to structure and position from them—in short a Geological Survey which shall do as much for Hypogean Geology as existing surveys have done for Epigean Geology, is now our crying need. Unless something of this sort is done, and done in a systematic and masterful manner, we run a great risk of frittering away the most important of our national resources left to us, of destroying confidence, of wasting time and money at a most precious and critical period of our history, and of slipping downhill at a time when our equipment and resources are ready to enable us to stride forward.

We do not want to be in the position of a certain town council which kept a list of its old workmen and entered opposite one, formerly sewer inspector, that he possessed 'an extensive memory which is at the disposal of the corporation.'

Even supposing the scheme outlined by Mr. Harmer cannot be carried out in its complete form, a great deal will be done if mining engineers can receive a sufficient geological training to enable them to realise the significance of these underground problems, so that they can recognise when any exploration they are carrying out inside their own area is likely to be of far-reaching geological and economic significance outside the immediate district in which they are personally and immediately concerned.

Turning to our colonies it is true that in many of them much is being done by competent surveys to attain a knowledge of mineral resources, but this work should be pushed forward more rapidly, with greater strength and larger staffs, and above all it should not be limited to areas that happen to be of known economic value just at the present moment. It is almost a truism that the scientific principle of to-day is the economic instrument of to-morrow, and it will be a good investment to enlarge the bounds of geological theory, trusting to the inevitable result that every new principle and fact discovered will soon find its economic application. Further, it is necessary that we should obtain as soon as possible a better knowledge of the mineral resources of the smaller and thinly inhabited colonies, protectorates, and spheres of influence: This is one of the things which would conduce to the more rapid, effective occupation of these areas.

With regard to areas not at present British colonies, it seems to me that no great harm would be done by obtaining, not in any obtrusive way, some general knowledge of the mineral resources of likely areas. This at least seems to be what

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other nations find it worth their while to do, and then, when the opportunity of selection arises, they are able to choose such regions as will most rapidly fill up and soonest yield a return for the private or public capital invested in them.

Summary.

To sum up, I consider that the time has come when geologists should make a firm and consistent stand for the teaching of their science in schools, technical colleges, and universities. Such an extension of teaching will of course need the expenditure of time and money; but England is at last beginning to wake up to the belief, now an axiom in Germany and America, that one of the best investments of money that can be made by the pious benefactor or by the State is that laid up at compound interest, 'where neither moth nor rust doth corrupt,' in the brains of its young men.

This knowledge has been an asset of monetary value to hosts of individuals who have made their great wealth by the utilisation of our mineral resources, and to our country, which owes its high position among the nations to the power and importance given to it by its coal and iron. It is surely good advice to individuals and to the State to ask them to reinvest some of their savings in the business which has already given such excellent returns, so that they and we may not be losers through our lack of knowledge of those sources of energy which have made us what we are, and are capable of keeping for many years the position they have won for us.

And in our present revival of education it would be well that its rightful position should be given to a science which is useful in training and exercising the faculty of observation and the power of reasoning, which conduces to the open-air life and to the appreciation of the beautiful in nature, which places its services at the disposal of the allied sciences of topography and geography, which is the handmaid of many of the useful arts, and which brings about a better knowledge and appreciation of the life and growth of the planet that we inhabit for a while, and wish to hand on to our descendants as little impaired in vitality and energy as is consistent with the economic use of our own life-interest in it.

The following Papers and Reports were read:—

1. *The Geology of the Country round Southport.*
By J. Lomas, *A.R.C.S., F.G.S.*

Looking towards Southport from the sea we notice three platforms rising in gigantic steps towards the east.

The first is low, varying in height from 9 to 20 feet above Ordnance datum, and is fringed on the seaward side by sandhills which rise to an elevation of from 50 to 90 feet. On the north the broad estuary of the Ribble separates this plain from a similar platform known as the Fylde district, and the Mersey on the south cuts off another fragment which forms the north end of the Wirral. Two less significant streams, the Douglas and the Alt, flow across the platform into the Ribble Estuary and the Crosby Channel respectively.

The whole of this plain is the gift of the Irish Sea glacier, which formerly overrode the district, the solid rocks only reaching the surface in the case of a few islands, while the bulk is below sea level.

In the immediate neighbourhood of Southport, Keuper marls occur. These are of great thickness, and contain bands of gypsum and pseudomorphs of rock salt. To the north, in the Fylde district, where similar rocks occur, salt is obtained from the beds, and the boulders of gypsum which occur in great profusion in the local drift have evidently come from this formation.

The Bunter rocks of the Trias succeed to the east, and are in places capped by Keuper sandstones. Where these occur we reach the second platform.

At Ormskirk, distant about eight miles from Southport, several interesting sections show the Keuper resting on the Upper Bunter. At Scarth Hill, near the

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Water Tower, the relations beween Keuper and Bunter are well displayed, and the quarries are worth visiting. Probably nowhere in the district do the Bunter sandstones display such clear evidence of their æolian origin. They consist of sand grains perfectly rounded and polished, each bed containing grains of uniform size. So perfect is this sifting that it looks as if the layers had been passed through sieves of varying meshes. In some layers the grains are 2 mm. in diameter, and in others they are exceedingly fine. A comparison of these sands with others from the Sahara and sand dunes shows clearly the distinction between the deposition by wind agency and in water. Faults traversing the Triassic rocks conform to the general N. and S. direction so characteristic of Lancashire and Cheshire, and these are joined by E. and W. faults, which, as a rule, have little or no throw. It seems as if the N. and S. buckling which caused the main faults had cut up the rocks into blocks, and the E. and W. faults mark the units which dropped successively in the individual blocks.

Further to the E. the Bunter rocks give place to Coal-measures, but at one or two places in the area, as at Skillaw Clough and Bentley Brook, thin beds of Permian age intervene.

Succeeding the Coal-measures, Millstone Grit appears in the next platform which forms the hills above Chorley and Horwich. An outlier of Millstone Grit also occurs at Parbold, further to the west.

The disposition of the rocks already given indicates an approach towards the arch of the great Penine anticline, and on crossing the Penine chain a similar succession, in the reverse order, is met with in Yorkshire.

The matter is complicated, however, by the occurrence of another line of folding which shows itself in the Rosendale anticline, running E.N.E. to W.S.W.; and it is owing to this cross folding that the Millstone Grit is brought to the surface on Anglezark Moor and at Parbold.

As a result of this folding the main faults in the Carboniferous area run parallel with the anticline, and the cross faults at right angles to the faulted blocks are characterised by having only a slight throw.

Returning now to the first platform we find the chief interest lies in the glacial and post-glacial deposits which cover the area. The surface of the boulder clay is very uneven, and in the hollows meres have been formed. Many of these have since been filled with peat, and tree trunks, both prone and erect, are found inclosed in it. A great number of these meres, or mosses, are seen, not only about Southport, but in the Fylde, in South Lancashire, and the northern part of Cheshire.

In all cases they either drain eastwards or formerly did so. Borings in the peat show that they often extend below sea-level, and there must have existed barriers which prevented the waters from reaching the Irish Sea. It has been estimated that the coasts in the neighbourhood are being eroded, in some places at the rate of five yards a year; so that 400 years ago the land would extend more than a mile seawards; and if the same rate of waste has obtained since the glacial period there would be a land of meres and mosses extending as far as the Isle of Man. It is possible that the Irish elk found in the Isle of Man crossed by this lost land.

Along the coast meres can be seen in all stages of decay. Immediately to the east of Southport lies Martin Mere, which is only separated from the sea by a narrow bank at Crossens. At the Alt mouth, at Leasowe, in Cheshire, and in other places, the ancient meres have been cut in two by the sea, and we have peat and tree trunks on the coast below high-water level. These are usually spoken of as 'submerged forests,' and their occurrence in the places mentioned may indicate a lowering of the surface of the land since the trees grew.

The present mouths of the Mersey, Alt, Douglas, and Ribble have all been cut through ancient meres, and as there is evidence that these formerly drained to the east it is probable that the breaching of the meres has resulted in a reversal of flow since glacial times, and the present mouths are of comparatively recent date.

The sandhills on the coast only occur in districts adjacent to rivers. It is probable that they owe their origin to the material brought down by the rivers,

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forming a bank of sand in the slack water at each side of their channels. These banks drying at low water, the sand has then been blown inland by the prevailing S.W. winds. No dunes existed in this district 400 years ago, and they are probably subsequent to and result from the reversal of the drainage of the Mersey and Ribble.

2. *Martin Mere.* *By* HAROLD BRODRICK, *M.A.*

Martin Mere, a lake situated inland of and to the N.E. of Southport, was, at the end of the sixteenth century, about four miles long by two in width, its length extending from Crossens to Rufford. It was one of a number of lakes which formerly existed in this district, such as the lake on the site of Chat Moss and others in the Wirral Peninsula. The glacial period left the whole of this district and part of the Irish Sea between the present coast line and the Isle of Man covered with a deposit of boulder clay with an undulating surface. The district under consideration seems to have formed a portion either of a large lake basin, which stretched seawards, or of an estuary, as a deposit of grey clay is found underlying the western portion of the mere; the lacustrine or estuarine character of this clay is not at present fully determined. Subsequently to this deposit a good drainage system came into existence, and a forest sprang up consisting of gigantic oaks and Scotch firs, the roots of which trees penetrated through the grey clay, and in some cases imbedded themselves in the underlying boulder clay. This forest covered a considerable area of South-west Lancashire and the Wirral Peninsula and extended seawards of the present coast line. The drainage of this district became obstructed by a bank of tidal alluvium at Crossens, and a lake was formed killing the trees, which fell mostly pointing in a N.E. direction. This lake slowly became smaller owing to the growth of sphagnum and other peat-forming plants; the shores, with the exception of that on the north, were shallow and marshy, and favourable to such growths. The old basin is filled with peat, the lowest layers of which are of a dense black nature containing the trunks of trees; the upper portions of the peat are of a light colour, and contain no tree trunks for the most part, although a layer of hazel trees occurs within a few feet of the surface over the greater portion of the area; shallow layers of sand occur in various places in the peat, and are probably of similar origin to that of the Shirdley Hill sand of the district. The greatest depth of the peat so far ascertained is nineteen feet. Imbedded within a few feet of the surface fifteen canoes, each hollowed out of a single tree trunk, have been found. The earlier maps (*e.g.*, Blaeu, 1662) all show three islands: of these the boulder clay knoll on which Berry House windmill stands is one. It is possible that Wyke Farm occupies a second and Clay Brow a third. Berry House Island was never more than five feet above the highest waters of the mere. The lake prior to the artificial drainage flowed into the Douglas near Rufford; but it is likely that in times of floods the reverse took place, and the flood waters of the river and of the lake found their way into the sea at Crossens. In 1692 the first artificial drainage works were commenced, and consisted of a canal, cut through the banked alluvium at Crossens, and flood gates. It was not until about 1850 that the lake was efficiently drained. Previous to that date the area was frequently flooded, partly owing to the blocking of the flood gates by sand, partly to incursions of the sea, and partly to floods from the Douglas. The present area of the old lake is now below the high-water mark of spring tides, which have been known, within living memory, to flow up as far as Berry House.

3. *Report of the Committee on the Registration of Type Specimens of Fossils.*

4. *Report of the Committee on the Structure of Crystals.*

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FRIDAY, SEPTEMBER 11.

The following Papers and Reports were read:—

1. *On the Lakes of the Upper Engadine.* *By* ANDRÉ DELEBECQUE.

One of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja.

It is occupied by the four lakes of Sils, Silva Plana, Campfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively.

The level of these lakes ranges between 1,771 and 1,800 metres.

The lake of St. Moriz is obviously in a rock-basin.

As to the other three lakes, an opinion currently prevails which, though supported by the high authority of Professor Heim, is believed by the author to be unjustified. It is generally thought that the river Inn, weakened by the capture of some of its tributaries by the river Maira, has been unable to sweep away the deposits of the torrents descending from lateral valleys, and that consequently its waters have been dammed up into the three lakes in question.

An attentive survey of the region shows that, on the contrary, these lakes formerly constituted a single sheet of water in a rock basin, which extended from the Maloja to the village of Campfer, in both of which places ledges of gneiss are visible, and that the lateral torrents, far from contributing to the formation of the lakes, have partly filled them up by their deposits, and have divided into three what was originally a single basin.

The length of the original lake was remarkable, as it measured no less than 12 kilometres (7½ miles), and it must be borne in mind that, though mountain lakes are often very deep, their horizontal dimensions are generally limited.

As to the origin of the lake, the author is of opinion that it cannot be attributed to tectonic movements or to aqueous erosion, and that very probably glacial excavation has come into play.

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2. *On a Preglacial or Early Glacial Raised Beach in County Cork.* *By* H. B. MUFF, *B.A., F.G.S., and* W. B. WRIGHT, *B.A., of H.M. Geological Survey.*

[Communicated with the permission of the Director of H.M. Geological Survey.]

The existence of a raised beach formed, and probably elevated, before the deposition of the boulder-clay has already been demonstrated in South Wales[1] and Yorkshire.[2] During the progress of the Drift Survey of the country surrounding Queenstown Harbour a beach of similar age was observed along the shores of the harbour, and was subsequently traced at intervals along the adjoining coast of Waterford and Cork from Ballyvoyle Head, Dungarvan, to Clonakilty, a distance from east to west of about sixty miles.

The relation of this beach to the well-known submerged river valleys of the south of Ireland is a point of considerable interest. The finding of glacial drift and striæ within the valleys led at once to the recognition of their preglacial excavation, but the subsequent tracing of the raised beach beneath the boulder-clay along their banks showed that their submergence was also preglacial.

The most persistent relic of the raised beach is a water-worn rock-platform, of

[1] R. H. Tiddeman, M.A., F.G.S., 'On the Age of the Raised Beach of Southern Britain as seen in Gower,' *Rep. Brit. Assoc.*, 1900, p. 760. See also *Summary of Progress of the Geological Survey of the United Kingdom for* 1899, pp. 154, 155.

[2] G. W. Lamplugh, F.G.S., 'Report of the Committee appointed for the Purpose of investigating an Ancient Sea-beach near Bridlington Quay,' *Rep. Brit. Assoc.*, 1890, p. 375. See also *Proc. Yorkshire Geol. and Polytechnic Society*, 1887, p. 381; and 'The Drifts of Flamborough Head,' *Quart. Journ. Geol. Soc.*, xlvii. p. 384

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varying width, sloping gently seaward and terminated at its landward side by a rocky cliff against which the deposits overlying the beach are banked. The higher portions of this platform, just at the foot of the cliff, are from five to ten feet above high-water mark—that is, perhaps seven to twelve feet above the higher portions of the corresponding plane of erosion in process of formation at the present day.

The overlying deposits, where completely developed, exhibit the following succession of strata:—

5. Upper 'head.'
4. Boulder-clay.
3. Lower 'head.'
2. Blown sand.
1. Raised-beach shingle and blocks from cliff.
   Rock platform.

The 'head' is composed of angular fragments of rocks similar in character to those forming the cliffs above. It has a bedded appearance, like that of a tip-heap, but there is no sorting of material. By far the greater proportion of it lies below the boulder-clay. The upper 'head' often contains rounded stones derived from the drift.

The boulder-clay contains well-scratched subangular stones, all local, but much more miscellaneous than those in the 'head.'

The blown sand is found banked against the cliff behind the 'head,' which has the appearance of having slipped down little by little over it. The rock cliff often has a polished appearance, probably due to the action of the wind-borne sand.

The shingle lies upon the platform among the blocks, which have evidently fallen from the cliff above. The blown sand is heaped over and among these blocks, which are absent in sections further from the old cliff. The shingle in these seaward sections is often replaced by fine stratified beach-sand.

As the present coast-line recedes from the old cliff, the 'head,' both upper and lower, is seen to thin out and finally disappear. The boulder-clay, on the other hand, thickens at first to seaward, until it replaces the 'head' and comes to lie directly on the rock platform, which is often beautifully glaciated beneath it. When sufficiently preserved, however, it can be seen to thin out further seaward, having in section a somewhat lenticular shape.

The sections are, of course, not always as complete as indicated above. Sometimes one member is absent, sometimes another, but the relative succession is invariable. With the exception of a few fragmentary shells no fossils have up to the present been found in any of the deposits.

The superposition of the boulder-clay and the glaciation of the rock platform are taken to prove the preglacial—or, more strictly, the pre-boulder-clay—age of the beach.

The occurrence of blown sand and lower 'head' indicates an elevation of the beach prior to the deposition of the boulder-clay.

The preponderance of the lower over the upper 'head' is no doubt due to the greater steepness in preglacial times of the dominating cliff or slope from which the 'head' was derived. It is as a consequence not to be taken as any indication of a longer lapse of time between the elevation of the beach and the period of glaciation than between that period and the present day. On the contrary, the occurrence of flints in the beach near Clonakilty points to the presence of floating ice during its formation, and indicates a beginning of glacial conditions even before the commencement of the elevation.

In Ballycroneen Bay a section of more than usual interest is exposed. The 'head,' which here rests immediately on the rock-ledge, is overlain by two distinct boulder-clays. The lower of these contains shell-fragments, chalk flints, and boulders of Wexford and Waterford rocks, and is obviously the boulder-clay of the Irish Sea Ice. The upper is the ordinary local boulder-clay of the district laid down by the ice which moved from west to east over Cork. The beach is therefore prior to both these ice-flows.

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The relative succession of events for which evidence has been obtained appears to have been as follows:—

1. Land higher than at present—erosion of valleys now submerged.
2. Land depressed to about eight or ten feet below present level—formation of preglacial raised beach.
3. Elevation of land—accumulation of blown sand, and subsequently of lower 'head.'
4. Advance of the Irish Sea Ice from the east at least as far as Power Head, and deposition of marly boulder-clay, followed by advance of ice from West Cork and deposition of upper 'local' boulder-clay.
5. Accumulation of upper 'head.'

Finally we would call attention to the complete similarity of the preglacial beach to that of Gower in South Wales described by Mr. Tiddeman. The only difference worthy of notice is the apparent absence of fossils in the Cork beach—a difference which is easily accounted for by the quantity of spring water which issues along the platform through the gravel and sand of the beach.

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3. *Land Shells in the Infra-Glacial Chalk-rubble at Sewerby, near Bridlington.*[1] *By* G. W. Lamplugh, *F.G.S.*

The Chalk-rubble which underlies the glacial drifts of Flamborough Head has not hitherto been known to contain organic remains. In a recent exposure of this material on the foreshore between Bridlington Quay and Sewerby the writer found numerous small fragile land-shells contained principally in intercalated streaks of brown earth. These shells belong mainly, if not entirely, to the species *Pupa muscorum*, Linn. The level at which they were found was about 8 feet below the top of the Sewerby Infra-Glacial Sea-beach, and the Chalk-rubble is known to descend to at least 25 feet below this level.

The rubble usually rests directly upon the Chalk, but at Sewerby it overlies the Infra-Glacial blown sand which is banked against the buried cliff of chalk. The presence of the land-shells proves that the rubble is a sub-aërial rain-wash, and that it was formed when the sea stood at a lower level than when the Infra-Glacial Beach was deposited. The conditions thus indicated are strikingly similar to those which obtain in the deposits associated with the Infra-Glacial buried shores of South Wales and co. Cork, where the old marine beaches and the accompanying blown-sand are covered by local rain-wash or 'head' and then by boulder-clay.

The Chalk-rubble at Sewerby contains many small pieces of flint, though no flint is present in the Chalk within two miles of this locality; a few small fragments of yellow grit or quartzite foreign to the neighbourhood, along with one subangular boulder of similar rock 18 inches in diameter, and two or three small decomposed pebbles of basalt, were also found in it. Part of the material was probably deposited almost immediately before the glaciation of the district.

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4. *Preliminary Report of the Committee on the Estuarine Deposits at Kirmington, Lincolnshire.*—See Reports, p. 218.

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5. *Report of the Committee on Erratic Blocks.*—See Reports, p. 231.

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6. *Report of the Committee to Explore Irish Caves.*—See Reports, p. 183.

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[1] The full text of this paper will be published in *Proc. Yorks. Geol. and Polytech. Society.*

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7. *Report of the Committee on Underground Waters of North-west Yorkshire.* See Reports, p. 192.

8. *Report of the Committee on Geological Photographs.* See Reports, p. 197.

9. *On the Practical Value of certain Species of Molluscs in the Coal Measures.* By WHEELTON HIND, *M.D., F.R.C.S., F.G.S.*

10. *Report of the Committee on Life Zones in the British Carboniferous Rocks.*—See Reports, p. 185.

11. *On some Igneous Rocks near Weston-super-Mare, Somersetshire.* By W. S. BOULTON, *B.Sc., A.R.C.S., F.G.S.*

The Paper dealt with a summary of the results obtained by the author after a study of the basaltic lava flow in the carboniferous limestone at Spring Cove, Weston-super-Mare, the evidence for the contemporaneity of which was first published in the Summary of Progress of the Geological Survey for 1898.

After referring to the complex character of the flow, and its relation to the carboniferous limestone beds above and below, with the contact phenomena and the metasomatic changes in the limestone subsequent to the consolidation of the basalt, three characters were emphasised and described: (1) the 'pillow' structure; (2) the tuffy or agglomeratic structure within the flow; (3) the included lumps and masses of limestone.

In general, the pillowy masses, themselves often compound, are embedded in a tuffy material of the nature of volcanic sand, while in some parts great lenticular bands occur, made up of coarse agglomerate, containing lumps of slaggy basalt and limestone, and with a pronounced fluxional structure. In all cases the tuff, within the limits of the sheet, behaves as a lava and has flowed, and was not the result of sedimentation.

Illustrations were shown of irregular masses of oolitic and fossiliferous limestone up to 12 feet across in between the spheroidal masses of basalt, and evidence was adduced to show that this included limestone was derived from the underlying calcareous floor, when a sea-bottom, probably in a powdery or plastic condition, and was rolled in or picked up by the lava, and was able to accommodate itself in between the moving and distending spheroidal masses.

In conclusion, reference was made to other pillowy lavas containing sedimentary material, and the author emphasised the difficulty of distinguishing such submarine flows from sills or intrusive sheets, where, as Professor Lapworth has suggested, we may get tuffs, lava, and included masses of sedimentary material confusedly mixed and drawn out into lenticles as here described.

MONDAY, SEPTEMBER 14.

The following Papers and Report were read:—

1. *On Dedolomitisation.* By J. J. H. TEALL, *M.A., F.R.S., Director of the Geological Survey.*

The Durness dolomites as they approach the plutonic complex of Cnoc-na-Sroine become transformed into a white marble which generally contains one or more of

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the following minerals: forsterite, or serpentine after forsterite, tremolite, diopside, and brucite. The dominant carbonate of the marble is calcite, but dolomite occurs in variable quantity. The amount of dolomite decreases as the total amount of the magnesian silicates and brucite increases. The original dolomite contains a variable amount of silica in the form of chert.

When the altered rocks are examined under the microscope it is seen that forsterite, serpentine, and tremolite are invariably associated with calcite, but that diopside is sometimes associated with dolomite. These facts of paragenesis can be easily accounted for if we assume that the silica of the original dolomitic rock has combined with the bases of the carbonate, and preferably with the magnesia, for diopside is rare. Thus forsterite, a magnesian silicate, cannot have been formed in the dolomite without the liberation of lime, and consequently we find either detached crystals of forsterite surrounded by aureoles of calcite in a matrix of dolomite, or, when forsterite is abundant, a simple aggregate of forsterite and calcite; the formation of tremolite in which the ratio of CaO : MgO is 1 : 3 also implies the separation of lime from magnesia; and it is invariably found, like the forsterite, in direct contact with calcite. But in diopside the ratio of CaO : MgO is the same as in dolomite; so that in accordance with the principles above explained we should expect to find these two minerals in contact, and this has been observed.

The above facts clearly point to the conclusion that the cherty dolomites have been dedolomitised by the formation of magnesian silicates. Carbonic acid has been driven off, but the ratio of the bases has not been disturbed. The ratio of CaO : MgO in the altered as in the unaltered rocks is approximately 1 : 1.

But dedolomitisation has also been produced in another way. Certain varieties of the marble are composed of calcite and brucite. The brucite is probably a pseudomorph after periclase, just as the serpentine is a pseudomorph after forsterite. We are therefore compelled to conclude that, under the conditions which prevailed during the intrusion of the plutonic rocks, the carbonic acid freed itself more readily from the magnesia than from the lime; thus, in the absence of silica, giving rise to the formation of periclase and converting the original dolomite into an aggregate calcite and periclase, the latter mineral subsequently being changed to brucite. The resulting rock is identical with the well-known predazzite of the Tyrol, which was probably formed in a similar way.

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2. *Fossil Floras of South Africa.* By A. C. Seward, *F.R.S.*

1. *Uitenhage Flora.*—The plants from the Uitenhage series of Cape Colony include types characteristic of Wealden and others more closely allied to Jurassic species. On the whole there is a balance of evidence in favour of a Wealden horizon.

Onychiopsis Mantelli (Brongn.)
Cladophlebis Browniana (Dunk.)
Cladophlebis denticulata (Brongn.) forma *Atherstonei*.
Sphenopteris Fittoni, Sew.
Sphenopteris sp.
Tæniopteris sp.
Zamites recta (Tate).
Zamites Morrisii (Tate).
Zamites africana (Tate).
Zamites Rubidgei (Tate).
Nilssonia Tatei sp. nov.
Cycadolepis Jenkinsiana (Tate).
Benstedtia sp. (cf. *Coniferocaulon Columbeæforme*, Fliche).
Carpolithes sp.
Araucarites Rogersi sp. nov.
Taxites sp.
Brachyphyllum sp.
Conites sp. α.
Conites sp. β.
Coniferous wood.
Planta incertæ sedis.

2. *Stormberg Flora.*—The plants from the Stormberg series point to a flora of Rhætic age. The Rhætic vegetation, of which remnants have been recorded from Scania, Franconia, and other parts of Germany, North America, New Mexico,

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Honduras, Tonkin, China, Turkestan, India, Australia, South America, and elsewhere, was characterised by its uniform character throughout the world.

Schizoneura Krasseri sp. nov.
Strobolites sp.
Thinnfeldia odonopteroides (Morr.)
Thinnfeldia rhomboidalis, Ett.
Cladophlebis sp. (Feistmantel).
Callipteridium stormbergense sp. nov.
Tæniopteris Carruthersi, Ten.-Woods.
Chiropteris cuneata (Carr.)
Chiropteris Zeilleri sp. nov.
Baiera stormbergensis.
Baiera Schencki, Feist.
Phænicopsis elongatus (Morr.)
Stenopteris elongata (Carr.)

3. *Permo-Carboniferous Flora of Vereeniging.*—The conclusion to be drawn from the Vereeniging plants is that they belong to a flora which flourished in South Africa, India, South America, and Australia during some portion of the Permo-Carboniferous epoch. On the whole, it would seem probable that the age of the plant-beds corresponds most nearly with the Upper Carboniferous period as represented in Europe. It is of necessity difficult to attempt to express the geological age or homotaxy of South African beds in terms of the geological chronology of the Northern Hemisphere, but the close correspondence of some of the Vereeniging types with Indian and South American species points to their correlation with the Karharbari beds of the Lower Gondwana system. The occurrence of such types as *Sigillaria*, *Bothrodendron*, and *Psygmophyllum* shows a closer correspondence between the South African flora and that of the Northern Hemisphere than occurs in the Indian vegetation. We have evidence of an overlapping or commingling of the northern and southern botanical provinces in South Africa and in South America that is not afforded by the Lower Gondwana floras of India and Australia.

Glossopteris Browniana, Brongn.

Under this head may be included—at least for present purposes—
G. indica and *G. angustifolia*.
Gangamopteris cyclopteroides, Feist.
Sphenopteris sp.
Neuropteridium validum, Feist.
Psygmophyllum Kidstoni sp. nov.
Sigillara Brardi, Brongn.
Bothrodendron Leslii sp. nov.
Naeggerathiopsis Hislopi, Bunb.
Conites sp.
Cardiocarpus sp.
Phyllotheca sp.
Schizoneura sp.

A detailed account of the above species will be published in a forthcoming volume of the Annals of the South African Museum.[1] The writer is indebted to the officers of the Geological Survey of Cape Colony for the opportunity of examining the collections from which these lists have been compiled.

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3. *On a Carboniferous Acanthodian Fish*, Gyracanthides. *By* A. Smith Woodward, *LL.D.*, *F.R.S.*

The author exhibited and described a restored drawing of *Gyracanthides* from the Carboniferous of Victoria, Australia. The fossil had pectoral fin-spines much like those named *Gyracanthus* from the Carboniferous of the northern hemisphere, but these spines lacked posterior denticles. The fish was either toothless or with minute teeth which had escaped observation. It was covered with dense shagreen, but there were no enlarged plates round the eyes. The body was depressed and broad in front, with a small and not very stout tail. The pectoral fins were relatively large, with almost sickle-shaped spines, while the pelvic fins were rather small, with straighter spines, and situated very far forwards. There were two pairs of peculiar free spines near the base of the pectoral fins. The two dorsal fins and the anal fin were provided with much smaller spines. *Gyracanthides* was

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evidently one of the most highly specialised Acanthodians, and showed that among these primitive fishes, as among modern Teleosteans, there was a tendency for the pelvic pair of fins to become displaced forwards in the higher types. The author had already described the same phenomenon in the typical family Acanthodidæ.

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4. *On some Dinosaurian Bones from South Brazil.* *By* A. Smith Woodward, *LL.D., F.R.S.*

The author had received from Professor H. von Jhering a few cervical vertebræ and phalangeal bones of a reptile discovered by Dr. Fischer in red rocks in the province of Rio Grande do Sul, Brazil. He described these remains, and suggested that they belonged to a short-necked Dinosaur. The ungual phalanges were especially remarkable, apparently unique, in being deeply concave on their inferior face and having a very sharp rim. Comparison seemed to show that, among known Dinosaurs, the cervical vertebræ most closely resembled those of *Euskelesaurus* from the Karoo Formation of South Africa. The newly discovered bones were therefore probably the first traces of the Gondwana-land terrestrial fauna, the discovery of which had long been expected in South America.

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5. *On Polyzoa as Rock-cementing Organisms.* *By* J. Lomas, *A.R.C.S., F.G.S.*

Among the specimens of sea-bottoms recently brought from the Gulf of Manaar by Professor Herdman were about twenty samples of 'calcretes.' They were broken off by pearl divers from the parent masses which form rocky platforms, locally called 'paars,' in many parts of the gulf. They all occur in shallow water at depths varying from 2½ to 10 fathoms.

The majority of the specimens were sandstones cemented by carbonate of lime, but occasionally compact limestones, sometimes phosphatic, and coral rock were brought to the surface.

All the stones were thickly incrusted with organisms such as polyzoa, nullipores, worm tubes, sponges, &c.

While the importance of nullipores as agents in binding grains of sand has been recognised, the work of polyzoa has not hitherto been recorded. The thin calcareous walls of polyzoa so readily break up and lose their structural characters that it is only when very recent samples are at hand we can obtain criteria which determine their former presence.

On examining a thin slice of calcrete with recent colonies on the outside we find the surface layer shows sections of the cells arrayed like bricks in a wall and containing the zooid in the interior. The spines and avicularia bordering the cells entrap and retain sand grains drifting over them, only retaining those which fit into the spaces they provide. Thus a sifting takes place, and we see above the outer layer of cells grains of sand and foraminifera of fairly uniform size caught in the manner described. The cells forming the next layer below are nearly all filled with grains: the base and side walls are complete, but the top covering has broken down to admit the sand grains, carrying with it the thin calcareous wall and the chitinous operculum. Several layers of this kind succeed towards the interior, but as we proceed further, the walls become less prominent owing to secondary calcite being deposited, which grows in tiny scalenohedra towards the interior of the cells, and finally fills up all the corners and other spaces. When this stage has been reached we only have a thin dark line marking the junction of the double side walls, the roughly linear arrangement of uniform grains and occasional remains of the chitinous opercula to indicate the former presence of polyzoa

Further towards the interior of a thick block even these guides become less distinct; but the grains still retain a rudely linear arrangement, and cells which escape being occupied by a grain are filled with calcite.

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Nullipores also enclose sand grains in their stony tissues, but they are sporadic in their arrangement, and can readily be distinguished from those cemented by polyzoa.

In some cases alternate growths of nullipores and polyzoa colonies give both types in the same section.

Some of the blocks of calcrete brought up were of large size, 2 or 3 feet in diameter; and these are but samples of the rocks now being formed which extend in some of the paars over a distance of many miles.

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6. *On the Igneous Rocks of the Berwyns.* *By* T. H. Cope *and* J. Lomas.

Owing to cross folding a dome-like structure has been impressed on the Berwyns. From the axis which lies about Llanrhaiadr-yn-Mochnant and Craig-y-Glyn the beds dip outwards on every side. The arch of the dome has been denuded, so that we get shales and limestones of Llandeilo age occupying the central area, while slates, grits, and limestone of Bala age form an almost continuous ring of hills on the margins.

Igneous rocks are associated with the sedimentaries. Three bands in the peripheral series can be traced continuously for a distance of thirty miles from the Mountain Limestone beds which overlap the series on the east, through the hills above Corwen and Bala to the Vyrnwy watershed. A fourth band also occurs in this series about Llanarmon.

In the central area other igneous rocks are exposed, generally of a more acid type.

The igneous series have been regarded as contemporaneous volcanic ashes, and recorded as such in the Survey maps. We have failed to find any instance of undoubted contemporaneous action, and regard all the igneous as intrusive. In places they are seen to cut across the sedimentaries at right angles to the strike.

In this paper we only deal with a small part of the peripheral series as displayed about Llansantffraid-Glyn-Ceiriog where the river Ceiriog in cutting a deep gorge across the strike of the beds has exposed magnificent sections.

Sheet No. 1.—The outermost bed is well seen in the quarries at Coed-y-Glyn, on the west side of the valley, and in a small cutting on the hillside on the east side. It is 45 feet thick on the level of the road, but thins out rapidly to the north, as at a short distance away it only measures 28 feet. Baked slates lie in contact on both its upper and lower surfaces.

The rock consists of a felted aggregate of felspar microliths, and is aphanitic in texture. The upper margin for 5 feet and the lower part for 2 feet are amygdaloidal. Near the upper surface the microscope reveals flow-brecciation, broken fragments of the rock lying in a bond of grey translucent chalcedony.

Sheet No. 2.—This band, about 165 feet thick, has been quarried extensively on the face of the steep crags overlooking Pandy, at Cae Deicws, and in the large quarry opposite Coed-y-Glyn. Indurated slates and grits border the sill on both surfaces, and large masses of slate occur as inclusions. A band of white rock of very varying thickness occupies the middle, which under the microscope shows large idiomorphic quartz and orthoclase felspar crystals in a felsitic ground mass. The margins are intensely sheared, grey in colour, and include a great number of slate and limestone fragments along with angular pieces of the white uncleaved central portion.

Sheet No. 3.—This sheet is well seen in Coed Errwgerrig and can be traced across the bed of the river to the east side of the valley at Cwm Clwyd. While the main mass resembles Sheet No. 2 in composition, it includes fragments of quartz felsite, felsite breccias, and nodular rhyolites arranged in parallel bands.

It is 190 feet thick, and has caused intense metamorphic action on the grits above and slates below.

Sheet No. 4 is best seen at Hendre Quarry, where it is worked extensively, and locally known as the Glyn 'Granite.'

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It is an analcite-diabase, 96 feet thick, of coarse texture in the middle and finer grained towards the margins. The slates in contact are converted into compact spotted slate.

Intrusions of similar age and almost identical character have been described from Counties Donegal, Armagh, Wicklow, and other parts of Ireland, and a close parallelism can be drawn between these rocks and those in the Berwyns. The intrusions of Sheets Nos. 1, 2, and 3 probably date from the interval between the deposition of the Bala series and the overlying slates and grits of Wenlock age. No. 4 may be of a later date.

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7. *The Llanvirn Beds in Carnarvonshire.* *By* W. G. Fearnsides.[1]

The author gave a brief account of the occurrence of beds with tuning-fork graptolites from the following new localities in Carnarvonshire, which practically encircle the west and south-west sides of the so-called Snowdon Syncline:—(1) 100 yards N. of the house Tan-y-rhiwan, ½ mile E. of Criccieth; (2) 50 yards S.E. of farm Llewyn-y-mafon-uchaf, 1 mile S.E. of Dolbenmaen; (3) 100 yards N. of bridge over Dwyfawr, 1 mile N. of Llanfihangel-y-pennant; (4) 200 yards from outlet of Llyn-cwm-dulyn on both sides of lake; (5) tips from mine workings near Ffald, 2 miles S. of Nantlle; (6) manganese workings near Llyn-cwm-silyn; (7) and also in Cwm Tal-y-mignedd; (8) gully on S. side of Llyn Cwellyn, 300 yards N.W. of river entry; (9) Snowdon Ranger Hotel; (10) bifurcation of paths to Llanberis and Snowdon from Snowdon Ranger Hotel; (11) Bwlch-y-maes-cwm and the flanks of Moel-cynghorion and of Moel-goch for about a mile from the Bwlch; (12) Cwm Brwynog, 1 mile N. of Bwlch-y-cum-brwynog; (13) slate quarry trial about 200 yards N.W. of the halfway house on the Snowdon-Llanberis track.

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8. *On the Fossil Flora of the Ardwick Series of Manchester.* *By* E. A. Newell Arber, *M.A.*, *F.L.S.*, *F.G.S.*

The Ardwick Series of Manchester forms the highest portion of the Coal-measures of the great South Lancashire Coal-field. The plant remains in the shales associated with the Spirorbis Limestones of this series have been already mentioned or described by Williamson, Salter, and especially by the late E. W. Binney. A revision of these records has been recently undertaken with a view to determining the true position of the Ardwick Series in the Coal-measures as indicated by the character of the flora. For this purpose Binney's collection, now in the Sedgwick Museum, Cambridge, has been re-examined, and several further identifications have been made. The flora is found to belong to a palæobotanical horizon known as the Upper Transition Series, which is antecedent to the true Upper Coal-measures, and which is represented in several English and Welsh Coal-fields. The Lower Pennant Grits in the South Wales, and the New Rock and Vobster Series in the Somersetshire Coal-fields belong to this horizon.

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9. *Report of the Committee on the Fauna and Flora of the Trias of the British Isles.*—See Reports, p. 219.

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10. *On the Base of the Keuper in South Devon.* *By* Alex. Somervail.

The author, while appreciating and agreeing with the work of Dr. Irving and Professor Hull[2] on 'The Red Rocks of Devon,' takes exception to one point relating to the case of the Keuper.

[1] The Paper will be published in full in the *Geological Magazine*.

[2] *Quar. Jour. Geol. Soc.* vols. xliv., xlviii, and xlix.

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Both of these observers agree in regarding certain breccias occurring at the mouths of the rivers Otter and Sid as the base of the Keuper, the former of which the author accepts. The latter is explained as being the same breccias again brought up by the fault at the Chit Rock.

The writer regards the Sid section as on a far higher horizon than the Otterton one for the following reasons:—The Otterton breccias are overlaid by a great thickness of sandstones seen between Otterton Point, Ladrum Bay, the base of High Peak Hill, and even further east.

The fault at the Chit Rock only brings up the upper portion of these sandstones, the highest portions of which are continued to the east side of the Sid.

The alleged river Sid breccias here have no occurrence; they are only the uppermost beds of the red nobbly or concretionary-like sandstones which are almost immediately overlaid by the Keuper marls.

Between these alleged Sid breccias and the Otterton breccias there should intervene about 150 feet or more of the mottled or current-bedded sandstones seen in the localities already referred to.

TUESDAY, SEPTEMBER 15.

The following Papers were read:—

1. *On the Disturbance of Junction Beds from Differential Shrinkage and similar Local Causes during Consolidation. By* G. W. Lamplugh, *F.G.S.*

Upon returning to the investigation of comparatively undisturbed Mesozoic strata after having studied distortion-structures produced by earth-movement in Older Palæozoic rocks, the author's attention has been frequently arrested by local disturbances of the original bedding which cannot be assigned to the agency of deep-seated earth-movement, but are clearly due to minor stresses arising from some local cause in tracts limited in extent both horizontally and vertically.

These disturbances are most noticeable where thin bands of one kind of material are imbedded in thick deposits of another kind, and along the junctions where thick masses of different lithological character occur in stratigraphical sequence.

Examples of the first-mentioned condition are abundant in the Hastings beds of the Wealden formation, where thin layers of clay or shale interbedded with thick sands and sandstones are often disrupted into irregular patches and partly mixed with the enclosing sands. The second condition is frequently illustrated in junctions of the Lower Greensand with underlying clays, where strips have been torn from the irregular surface of the clay and dragged up for a few inches into the sands, as was seen in the recently widened railway cutting at Redhill and in the pit-sections at the Dover Colliery. Similar effects have often been supposed to denote the breaking-up of the surface below the junction by erosive agencies, but this explanation is rarely adequate.

While some of these local disturbances may have been caused by unequal loading within limited basins of sedimentation, in the manner discussed by E. Reyer,[1] the author is of opinion that in most cases they may be assigned to local stresses resulting in part from the differential contraction of sediments of diverse composition while losing their water of sedimentation, and in part from their unequal yielding under equal superincumbent load. Masses of peat, sand, clay and calcareous sediments accumulated under normal conditions must pass from the wet state to the consolidated or partly consolidated state with different time-rates and with different physical results; and we may expect to find signs of local tension and readjustment along the boundaries of such masses.

In thick wedges of strata which thin out rapidly, as, for example, in the

[1] *K. K. Geol. Reichsanstalt Wien; Jahrbuch*, xxxi. 1881, pp. 431–444.

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Triassic rocks of many localities and the Wealden and Lower Greensand of the south of England, differential shrinkage may be responsible for many of the smaller vertical displacements by which the beds are readjusted. Faults are sometimes found to dwindle and die out downward, and in certain cases these may be explicable as the result of unequal contraction in masses of irregular thickness.

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2. *On some Contorted Strata occurring on the Coast of Northumberland.* By J. G. Goodchild.

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3. *Some Facts bearing on the Origin of Eruptive Rocks.* By J. G. Goodchild.

The author exhibited a number of photographic slides in order to demonstrate that intrusive masses, as a rule, replace their own volume of the rocks they invade and do not cause displacement to any important extent. Hughes, and also Clough, had already published evidence to the same effect. Several of the hand-specimens that had been photographed were exhibited at the Meeting. In the course of nearly forty years' field experience he had never met with any intrusive rock whose mode of occurrence could not be explained by the theory that the rocks in question had been substituted for those whose place they had occupied. The older rocks had, obviously, been gradually removed, and the newer ones had been, concurrently, left in their place. He thought that it was only in those cases in which the pressure to be overcome had been below a certain (unknown) amount that actual displacement occurred. This might happen where a viscid magma was being forced into the loose materials in the outer parts of a volcano. These, however, are the parts of a volcano which rarely survive subsequent geological changes.

The mode of attack of the erosive magma was next illustrated by a series of views representing various unfinished stages in the process. These demonstrated that the intruding magma ate its way along any divisional planes in the rock invaded, and by physico-chemical processes the advancing wedges enlarged and extended forward, solely by peripheral solution, which ended by surrounding the part attacked by the fluid magma, and thus permitting the detached portions to float into the trunk stream.

Further stages in the process of mastication, digestion, and assimilation were shown by other slides, as well as by specimens exhibited at the Meeting.

Three or four slides of pseudo-dykes and sills were shown. These occur within fragmentary materials of volcanic origin. He considered that these clastic rocks had been softened in place and had subsequently reconsolidated in the massive form without change of position.

Finally, to account for the facts, he advanced the hypothesis that the chief agent concerned in bringing about these changes was water operating under pressure and at a moderately high temperature, in which were held in solution the substances dissolved in sea-water. These underwent concentration by the action of volcanoes, and in that state were competent not only to dissolve the constituents of rocks, but to add to sedimentary or other rocks the substances in which their composition is deficient as compared with that of the eruptive rocks. Slow diffusion and a circulatory movement of the whole magma equalised the composition of the compound. He thought that the sedimentary rocks thus affected could furnish the materials for those rocks in which felspar containing lime and soda predominate, while the acid series might have arisen in like manner from the solution of the granitic foundation of the Earth's Crust.

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4. *On a Possible Cause of the Lethal Effects produced by the Dust emitted during the Recent Volcanic Eruptions in the West Indies.* *By* J. G. GOODCHILD.

When volcanic materials are expelled into the air in the form of either lava streams or ejected fragments, some of their component minerals may be in a chemical state in which they are capable of combining with a higher percentage of oxygen than they contained when they left the volcanic vent. Two results would follow from such oxidation—one being the rise of temperature due to the heat of combination, the other, correlative to it, an abstraction of oxygen from the surrounding atmosphere proportionate in amount to the surface acted upon.

In the cases in which a large quantity of finely divided material in a more or less pumiceous state is suddenly discharged into the air the aggregate surface exposed to the atmosphere must be extremely large, and it appears likely that a quantity of oxygen proportionately great may be abstracted. The loss of oxygen is, of course, soon made good by diffusion from the areas around; but, for the time being, it appears possible that the air carried forward along with heavy discharges of volcanic dust, such as were ejected during the late eruptions in the West Indies, may have sustained their initial temperature for some time through oxidation, and may consequently have raised the temperature of the surrounding air to a very high point. Furthermore, the abstraction of so large a quantity of oxygen may have also helped to make the air around the stream of dust unsuitable for the support of life.

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5. *Notes on the Metalliferous Deposits of the South of Scotland.* *By* J. G. GOODCHILD *and* WILBERT GOODCHILD, *M.B.*

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6. *Notes on the Glacial Drainage of the Forest of Rossendale.* *By* A. JOWETT.

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7. *A Theory of the Origin of Continents and Ocean Basins.* *By* WILLIAM MACKIE, *M.A.*, *M.D.*

Whatever the conditions at present obtaining in the interior of the earth, it is naturally supposed to have originally passed through a stage in which the conditions would be represented by a solid, or potentially solid, nucleus, a slowly forming and slowly thickening acid crust, with a liquid and more or less basic interstratum. At first the crust would be sufficiently flexible to accommodate itself to the tidal movements of the subjacent liquid interstratum, but when it became too rigid to admit of this tidal movement it would be broken up, the fracture probably following certain fairly defined and assignable lines. It is argued that the fragments would not have 'gone under,' but would have remained with their surfaces at a considerably higher level than the surface of the magma, and have become so fixed by consolidation of the magma around them.

It is suggested that the first great breach in the crust followed the outline of the tidal protuberance, and was, in all probability, effected at some conjunction of the sun and moon with cataclysmal suddenness, the intervening crust being shivered into small fragments, these fragments being subsequently disposed of by fusion in and incorporation with the magma. The first oval breach thus caused is the prototype of the Pacific Ocean. Further fractures, along definite lines, gave rise to the other oceans, and caused the separation of the continents. Under the influence of tidal retardation the fragments as thus blocked out became separated and finally moored at their respective distances by the solidification of the magma around them.

With the resolidification of the crust, a series of stresses is set up between the ocean basins, which consist of the more basic, consequently specifically heavier,

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more quickly conducting material, and the more acid, specifically lighter, more slowly conducting continental masses. The former are, in consequence of their character and composition, the more stable portions of the resolidified crust. Further, cooling therefore leads to their sinking down on the cooling and shrinking nucleus, and their elbowing aside of the continental masses, which come to be elevated in lines parallel to and extending along their margins. With further cooling the superficial layers of the continents are thrown into folds and overfolds, which would tend to find relief along the ocean margins and the central axis of the Old World by over-thrusting of these layers. Central uplifts in the continental areas may also have resulted from such pressure.

The tendency of the ocean to become deeper and the continent to become more elevated as time goes on, leads more and more to the withdrawal of the waters of the ocean (which might at first almost or altogether have covered the continental areas) from these areas, and hence to greater and greater restriction in the limits of the areas of deposit as traced from earlier to later geological times.

The origins of the Mediterranean and of the central axis of the Old World are directly deduced from theory, and the unequal distribution of land and sea in the northern and southern hemispheres is also brought into line with it.

Though the contraction of the ocean basins has been the main cause of the deformation of the crust, the contraction of the continental areas has also had some share in the result. The central ridge of the Atlantic bottom may be an earth fold caused by pressure of the contiguous continental masses; but it may also be due to longitudinal fissures permitting volcanic action and consequent accumulation of volcanic products, the fissures in such case marking the relief of tension arising from the same cause.

The formation of secondary ridges parallel to the oceano-continental margins but at some distance towards the continental side, seems to have played an important part in the evolution. Extending oceanwards in their operation they appear in some instances to have raised up portions of the ocean bottom into continuity with the land surface. In this way, with the aid of volcanic action, the ocean basins appear, in not a few instances, to have been successfully bridged. As the permanency of the master-features of the globe in much their present form is a necessary corollary of the theory, such bridging of the ocean basins also becomes a necessary part of the theory, and is fairly met on the lines indicated.

Explaining as it does the general outlines of continents and ocean basins, as well as a large number of facts both in geography and geology, it is contended that the theory as sketched does represent in a general way the actual process by which the permanent features of the globe took origin.

WEDNESDAY, SEPTEMBER 16.

The following Report and Papers were read:—

1. *Report of the Committee on Changes in the Sea Coast of the United Kingdom.*—See Reports, p. 258.

2. *Notes on the Sarsen Stones of the Bagshot District.* *By* HORACE WOOLLASTON MONCKTON, *F.L.S., F.G.S.*

The blocks of sandstone or quartzite known as Sarsen Stones are found in many parts of the south of England. They occur at or near the surface of the ground, as well as in or at the bottom of the gravels. They are usually believed to be derived from the Bagshot or Reading Beds, but there does not seem to be definite evidence of the discovery of a Sarsen Stone *in situ* in these or in any other formation.

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Probably the best-known examples are the great stones which form the outer circle at Stonehenge. Sarsens are, however, frequently to be seen as gate-posts or corner-stones, and in some districts they have been used as building stone to a considerable extent.

Sarsens are very abundant in the neighbourhood of Bagshot. They have been observed by the author firstly, and most frequently, at the bottom of or close to the bottom of beds of gravel; secondly, and rather less often, at or near the surface of the ground where there is no gravel; and thirdly, but only seldom, in gravel some height above the bottom of the gravel. The author has never seen a Sarsen Stone *in situ*, for though he has seen many partially uncovered stones, they have in every case shown signs of wear by either water or weather. At the same time he has noticed that the corners are frequently angular, and many of the stones have been very slightly worn and certainly not rolled by water currents or streams. The country around Bagshot is formed of the Bagshot Beds, largely of Upper Bagshot Beds, which are shown by their fossils to be of Lower Barton age, and the author suggests that soon after their deposition this part of England rose somewhat above sea-level, and remained as a wide, fairly level, and low-lying flat covered with marsh and vegetation for a very long period. The Sarsen Stones are, he believes, indurated portions of this old land surface. If this is correct, it accounts for all the above-mentioned facts, and also for the presence of numerous rootlet tubes in the Stones, and for the absence of marine shells or of casts thereof.

If after a long period of repose an elevation of the land took place, the streams would rapidly cut channels in the sandy soil and leave the indurated fragments of the old surface scattered about at various levels, and many of these would become buried in the beds of gravel, thus accounting for the presence of the Sarsen Stones in the gravels.

It was suggested long ago by Mr. Hudleston that the concretionary action which formed the Sarsens was due to the decomposition of vegetable matter, and a somewhat similar opinion has been expressed by the Rev. Dr. Irving.[1]

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3. *On the Occurrence of Stone Implements in the Thames Valley between Reading and Maidenhead.* *By* Llewellyn Treacher, *F.G.S.*

Many neolithic celts have been obtained from the gravel of the bed of the present river at Tilehurst, Bourne End, and Maidenhead, but few at any intervening place. Surface finds are also more numerous in those localities than anywhere else in the district. There may have been fords or hunting resorts at these places in neolithic times, and the axe-heads may have been lost in the stream.

Palæolithic implements have been found abundantly in terrace gravels at heights of from 60 to 120 feet above the river on both sides of the valley. The places where they occur in greatest numbers are near Caversham, 115 feet; Grovelands, Reading, 75 feet; Sonning, 95 feet to 60 feet; Ruscombe, 60 feet; Cookham, 85 feet; and Furze Platt, near Maidenhead, 75 feet. From each of these localities more than 100 implements have been obtained, besides flakes and broken specimens. Flakes were very abundant at Caversham and at Furze Platt, while at Grovelands many bones and teeth of mammoth, horse, and deer were found.

Although there is considerable difference in the types of the implements from the various localities in the district, there is little evidence to show whether there was any progress or otherwise in their manufacture during the time their makers lived here. Those from Caversham at the highest level, and presumably the earliest, are more symmetrical in shape and have finer chipping on them than those from Furze Platt, 40 feet lower down, which often appear to have had only a few well-directed strokes given them to bring them to the desired shape. Taking the district as a whole, palæolithic implements occur together in groups in the older gravels, much in the same way as the neolithic ones do in the newer deposits. Caversham and Furze Platt may well have been palæolithic working sites.

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[1] See *Proc. Geol. Assoc* vol vii. p. 138, and vol. viii. p. 153.

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4. *On the Origin of certain Quartz Dykes in the Isle of Man.*
By J. LOMAS, *A.R.C.S., F.G.S.*

About Foxdale, I.O.M., the ground is strewn with blocks of quartz, and numerous quartz veins traverse the altered slates which form the structural anticline of the island. In nearly all cases these veins are accompanied by acid dykes having the same general trend.

Where the quartz traverses the granite mass at Foxdale, it is locally developed into a coarse pegmatite with idiomorphic crystals of felspar 3 inches long and mica over 1 inch in diameter.

Away from the granite the quartz is clear or milky, rudely columnar in structure, and on the joint faces sericite is common.

It is suggested that the quartz is a true injection resulting from an overplus of silica in the magma from which the granite crystallised.

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5. *Supplementary List of Minerals occurring in Ireland.*
By HENRY J. SEYMOUR, *B.A., F.G.S.*

The following species may be added to the list of Irish minerals published last year in the Report of the Belfast Meeting of the Association: Minium, Wad, Xanthosiderite, Strontianite, Nephelite, Scapolite, Orthite, Brewsterite, Zinnwaldite, Ripidolite, Halloysite, Mimetite, Retinite.

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6. *The Average Composition of the Igneous Rocks.*
By F. P. MENNELL, *F.G.S.*

The author has calculated the average composition of the igneous rocks occurring in a given district—that surrounding Bulawayo—taking into consideration the bulk of each type of rock present. Owing to the great preponderance in *bulk* of the granitic intrusions, despite their inferiority in *number* to those of other rocks, the result obtained for the average composition shows a silica percentage of 69·88, a number sensibly equal to that assumed for the granite (70 per cent.) The author considers that the same would certainly hold good for the whole of Rhodesia, and probably in general for any large representative area, and draws the conclusion that granite represents substantially the magma from which even the most basic rocks have been developed by some process of differentiation.

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Section D.—ZOOLOGY.

President of the Section—Professor Sydney J. Hickson, M.A., D.Sc., F.R.S.

The President delivered the following Address on Friday, September 11:—

At the last meeting of the British Association which was held in Southport, the President of Section D, Professor E. Ray Lankester, delivered an impressive address on the provision in this country for the advancement of Biological Science, in which he pointed out the very inadequate encouragement which existed at that time for those who, by education and inclination, were fitted to pursue original investigation in Zoology and Botany. Twenty years have passed since that Address was written, and yet we have to acknowledge that, notwithstanding the important part which our branch of Science has played in contributing to the sum of useful human knowledge during the last two decades, the progress made in the direction indicated by Professor Lankester is far from satisfactory. I do not propose in this Address to make any detailed statement of the number of posts in this country that are now open to zoologists, or of the amount of the present-day endowments for the encouragement of Zoological Science as compared with those of twenty years ago; but I wish to point out that neither in the older Universities of Oxford and Cambridge, nor in the Colleges and National Institutions situated in London, nor in the newer Universities and Colleges of the provinces, have any new posts been created or adequately endowed which enable the holder to devote a reasonable amount of his time to the pursuit of biological knowledge. It is true that there are a few more posts now than there were, in which a small stipend or salary is offered to young trained zoologists for their services as teachers of Elementary Biological Science to medical students and others; but the emoluments of such posts are so small, depending, as they do, almost entirely upon a share of the fees paid by the students, and the duties so arduous and prolonged, that they really offer very little inducement to the pursuit of continuous and systematic original research.

In one respect, however, we may notice and acknowledge, with gratitude, an improvement in our position. In the laboratory accommodation, both in our Universities and on the sea coast, we are a good deal better off than we were. Twenty years ago there was no biological laboratory on the whole of the long line of the British coast. Now, thanks to the efforts made by biologists and their friends, we have at Plymouth an institution for the study of the marine fauna and flora under favourable conditions, and similar institutions at Port Erin in the Isle of Man, at Piel, at Millport, and at St. Andrews, and a provisional laboratory for the study of fishery problems at Grimsby. New laboratories for the study of zoology have also been built at Oxford, at Cambridge, at the University of Manchester, at Edinburgh University, and elsewhere, and I may add that a fine new laboratory is now in course of construction for the department of Zoology in the University of Liverpool.

These new institutions, however, only emphasise, they certainly do not ameli-

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rate, the weakness of our position in having so little encouragement to offer to competent and well-trained men who wish to devote their lives to the advancement of Zoological Science. Moreover, I would point out that these institutions have been built and are being maintained almost entirely by funds supplied by private benefactors, or out of the inadequate resources of the Universities.

The Treasury has made a provisional grant of 1,000*l.* per annum towards the maintenance of the work done by the Marine Biological Association, and it may be supposed that a small share of the annual government grant made to the University Colleges and Scotch Universities goes to the support of the zoological departments; but, apart from this, there has been no increase in the support given to us from public funds.

If we were to compare our progress in the matter of the public appreciation of our science during the past two years with that in other countries, we should find that our position is by no means satisfactory. In Germany, France, Belgium, Holland, and more particularly in the United States of America, progress has been rapid and continuous. The number of persons in these countries who by the aid of university or public endowments are able to devote themselves to original work in zoology has considerably increased of late years, and the number of magnificently equipped institutions that have been built for their accommodation and convenience makes our efforts in the same direction appear very small.

It would not be difficult for me to bring facts and figures before you in support of these general statements; but my object is not so much to lament over the past and to mourn for the present position of our science in this country, as to suggest directions in which we may work together for its development and progress.

Upon one matter, however, I think we may congratulate ourselves. If the research done by English zoologists has not been as great in amount as it might have been, I think it may be truly said that we have fully maintained its standard as regards quality.

The contributions that have been made to the Science of Zoology by our countrymen during the past twenty years in general interest and in theoretical importance are of such a nature that any civilised race might well be proud of them, and I venture to say they compare favourably with those of any other country. I may remind you that the discovery and description of the Okapi, Cænolestes, Nyctotherus Rhabdopleura, Cephalodiscus, Limnocodium, and Pelagohydra, the rediscovery of Lepidosiren and Ctenoplana, the most important features of the development of Balanoglossus, Lepidosiren, Amphioxus, Peripatus Hatteria, and some of the Marsupialia, and that the discovery of the important character of the fauna of the deep seas involving the discovery of many new genera and species, were the work of British zoologists. Moreover, that the prolonged and painstaking investigations carried on in our laboratories have thrown much light upon the character and relations of cœlomic cavities, the homologies of the nephridia and genital ducts, and many other important morphological problems.

In the field of evolutionary theories we have done much important work in the study of the facts of protective and aggressive mimicry in insects, in the statistical estimation of variations, and in the experimental inquiry into the value of current theories of heredity.

The list is far from complete; but with such a record of good work done with the scanty means at our disposal there is no reason to suppose that the science is on the decline in this country, or that our countrymen are not as capable as any others of grasping the importance of biological problems and ultimately wresting from Nature the secrets that are hidden.

Whilst we may thus congratulate ourselves upon the achievements of the past and upon our strength and ability to carry on good work in the future, I cannot help feeling that the time has come for us to make a united effort to place before the general public of this country, and more particularly the educated and influential part of it, the disadvantages under which we suffer, and our need for help in the further development of our subject.

We have all realised that in this country, more than in any other that is called civilised, there prevails among all classes an extraordinary ignorance of the first

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principles of biological science. It is this ignorance on the part of the general public, I believe, which prevents us from gaining that sympathy for our aims and that assistance for our efforts which we think is necessary not only for the reputation, but also for the welfare of our country. We must remember that the science of Natural History is as a closed book to most of those who after a public school and university education have attained to positions of trust and responsibility in the government of our country and our cities. Moreover, and this is perhaps the most serious aspect of the question, there are many who have gained a high position as men of science, and whose opinion is frequently quoted as authoritative on questions affecting science in general, who are more ignorant of the first principles of the science of biology than the Dutch schoolboy of fifteen years of age.

It appears to me, then, that it is of fundamental importance for the zoologists of this country to consider and report upon the necessity for the extension and improvement of the teaching of Natural History in our schools and colleges. We shall have to meet the objections that there is not time for Natural History in the school curricula, and that it is not a suitable subject for the instruction of boys and girls. These objections can be met, I believe, and overcome.

In many foreign countries Natural History is a compulsory school subject for all scholars. In Holland, for example, by the law of April 28, 1876, all scholars of the gymnasia during the first and second years devote two hours per week to the study of Natural History, and in the fifth and sixth years all students preparing for natural, mathematical, and medical sciences courses devote two hours per week to the science. In the superior middle-class schools one hour a week is devoted to the science in the first and second classes, and two hours per week in the remaining three years. If, therefore, time can be found in the middle and upper class schools for the study of Natural History in a country like Holland, where the general education is so excellent, surely time can be found for it here.

It is also a matter for general regret that some course of Elementary Biology is no longer compulsory for those who are proceeding to degrees in science in our universities, and I cannot help feeling that a very retrograde step was taken a few years ago by the authorities of the University of London, when Biology was made an optional subject in the Intermediate Examination for the degree of Bachelor of Science. We cannot expect to receive that sympathy in our pursuits and appreciation of our discoveries which we expect from our fellow-men of science if we tacitly admit that an elementary knowledge of the laws of living bodies is not a necessary part of the equipment of a man of scientific culture.

I think we must all admit that the time is ripe for a full discussion by biologists of the particular form of teaching and study which is most suitable for schools and elementary university examinations. It is a matter in which we are all interested; it is a matter affecting most intimately the interests of those who will be our pupils in the future, and we should be careful to see that no ill-considered or fantastic schemes of study are thrust upon the authorities by unauthorised persons at this very critical period in the educational history of our country.

There are other matters, however, which also demand our careful attention. The growth of our great cities and the improvement in our ideas of sanitation have brought forward as important problems for consideration the purity of the water-supply and the disposal of sewage. The municipal authorities at last realise that these problems can only be satisfactorily met by elaborate scientific investigation, and they have found that it is not only desirable for sanitary reasons, but also—and this has probably the greater weight—profitable to call in men of science for consultation and advice. At present, however, these problems are approached from only two points of view—the chemical and the bacteriological—the effect or effects of other organisms than bacteria upon the character of the sewage effluent and the purity of water for drinking purposes being, so far as I have observed, neglected. I was very much impressed with the fact that at the meeting of the Sanitary Institute last year in Manchester the speakers used the expression 'bacteriological examination' and 'biological examination' as if they were synonymous, and no mention was made either of the animals or plants which are

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invariably present, and materially assist if they are not actually necessary for the maintenance of the most suitable balance of life in these waters. The time has come when an inquiry should be made of the organisms other than bacteria that are normally present both in the waters at the sewage works and in the large reservoirs which supply cities with drinking-water.

I may be allowed here to quote two cases that have recently come under my notice which will show the kind of work that might be done and the nature of the results which may be expected to follow such an inquiry.

Some years ago complaints were made that the water supplied by the borough of Burnley had an offensive smell. This smell was of such a nature that it was impossible to use the water for the manufacture of soda-water.

The smell was traced to the Hecknest reservoir, where the common water snail, *Limnæa peregra*, was present in enormous numbers. The problem to be solved was how to destroy or reduce the numbers of the Limnæa without interfering in other respects with the purity of the water. The authorities of the corporation asked the advice of a trained zoologist, who made certain recommendations which were adopted, and at a minimum cost the nuisance was abated, and during the six years that have elapsed has not recurred. I will not detain you with a full description of the cause and the cure of this particular pest, but I may say that the recommendations that were made were based on the knowledge of the life habits and reproduction of the Limnæa, and were therefore of a purely zoological character.

Two years ago the Chairman of the Water Committee of the Corporation of Manchester reported that the mains had become partially choked by the growth of an organism which he called a 'moss.' No less than 700 tons of this 'moss' were removed from the mains by a laborious and expensive process. It is not necessary for me to inform this Section that the organism was not a moss. It was probably not even a vegetable, but an animal belonging to one of the genera of fresh-water Polyzoa. In this case, however, so far as I am aware, not only were no steps taken to identify the organism, but no investigations were made to discover its origin or to prevent the return of the trouble in the future. I could give you several other examples which show that our ignorance of the general balance of animal and vegetable life in the large reservoirs is profound, and that a systematic inquiry conducted by competent persons would most certainly lead to knowledge which would be of great scientific importance, and in the long run remunerative to the community.

I do not think that we can expect that any one of the municipal authorities will feel justified in bearing the cost of such an investigation. The problems that one corporation has to face are very much the same as those that others have met; and each corporation hopes to profit by the successful and neglect the unsuccessful experiments of its neighbours. An investigation such as this, which is really for the benefit of the whole community, should be conducted by a central authority at the public expense.

The scientific investigation of the problems that are connected with the maintenance and extension of our sea fisheries is another matter that requires the very careful attention of the zoologists of the present day. The valuable work that has already been done by the officers of the British Marine Biological Association, the Lancashire Sea Fisheries Committee, the Scottish Fishery Board, and other bodies is of a nature sufficiently encouraging to justify us in asking for the necessary means and appliances for still further developments of the inquiry. There is, however, a great need for a free discussion by those who are competent to speak on the subject to determine and, if possible, to come to some conclusion upon the question of the best and most profitable lines that the inquiry should take in the immediate future, and the establishment of such co-operation as is necessary by the different authorities to prevent duplication where it is unnecessary, and simultaneous observations of similar phenomena on different parts of the coast when it is considered desirable. The report of the Committee on Ichthyological Research, 1902, has shown that there is already in this country a good deal of activity in various branches of investigation of the fisheries problems, but the authorities are not on all points in agreement as to the best plan or course to

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pursue in the future. I cannot but hope that if some conference were held, at which those zoologists who have made a special study of these matters were present, the principal differences of opinion might be cleared up and a unanimous report presented to the authorities.

I have felt very strongly for some time past, and I know there are many of my colleagues who agree with me, that the zoologists of this country are under some disadvantage in not being provided with the necessary machinery for full discussion of matters which affect the welfare of the science as a whole. There are several societies which receive, discuss, and publish papers on various branches of zoological research, but they do not, and from the nature of their constitution cannot, give effective utterance to the general or unanimous opinion of professional zoologists on matters of their common interests. There is no society which all serious students and teachers of zoology feel is the one society which it is their duty and in their own interests to join. Some join the Zoological Society of London, others the Linnean Society, others, again, the Royal Microscopical, Entomological, or Malacological Societies, or some combination of two or more of them. There is no common ground on which we meet for the discussion of such subjects as those I have just mentioned in this Address. In the early days of the British Association this Section supplied the needs which we feel now. It was the Society, if I may call it such, which all the zoologists of the time made a special effort to attend. Important matters were fully discussed by the most competent authorities, and people felt that the prevalent opinion on any subject expressed by Section D was the prevalent opinion of men of science throughout the country.

In concluding this portion of my Address, I may express the hope that when the Association meets next year at Cambridge some steps may be taken to render the organisation which we already possess in connection with this Section more generally useful and more efficacious than it is at present.

In the opening sentences of my Address I used an expression which some of my hearers may have considered open to criticism. Let me take this opportunity of saying, then, that by using the expression 'useful human knowledge' I did not intend to express an opinion that there is any knowledge of the character that is expounded and discussed in these sections of the Association which can be called useless knowledge.

A distinction, however, is frequently drawn between knowledge that can be directly applied to the arts and crafts and knowledge which, on the face of it, appears to us at present to be only of general scientific interest. For example, in the award of the Exhibition (1851) Scholarships and Bursaries, the candidates must still give evidence of capacity for advancing science or its application by original research in some branch of science, *the extension of which is especially important to our national industries.* We can rejoice most cordially in the successful developments of the technical institutions in the country, we can heartily join hands with our colleagues in other sciences in urging upon the authorities the encouragement of those branches of science which have a direct bearing upon our industries, but we have a no less important duty to perform in claiming for those branches of sciences that have apparently no such direct application the needful sympathy and encouragement. I venture to say that at the time the Association last met in Southport no one would have ventured to predict that the study of the anatomy and life history of the Diptera, or the general biology of the minute sporozoa, would have any direct bearing upon the development of our industries. But to-day, by our knowledge of the mosquito Anopheles, and the sporozoan parasite it carries, we are in a position to destroy or ameliorate the malaria pest which has hindered the commercial development of so many of our colonies in tropical countries, and by encouraging the development of such countries we are assisting to a very material extent our home industries and the general trade of the country. In this, as in so many other cases, the benefit to industry and commerce has come from an unexpected quarter of the field of zoological research. Those who were working within the narrow limits of what is called applied science could have never discovered the facts which we now regard as of extreme

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importance, however well equipped they were with laboratories and appliances and endowments for research.

It will be of very little profit to this country to endow munificently the technical institutions and those branches of science to which the adjective 'applied' is given, to build British 'Charlottenburgs,' and to attract by handsome salaries the most distinguished professors to the study of the application of science, if at the same time we starve and allow to sink into insignificance the fundamental sciences upon which the whole superstructure rests. It does not need a prophet to foretell that a great disaster will occur if we add story to story of our house of education without widening and broadening the basis upon which it rests.

Many of us, I am afraid, are too much inclined to believe that the intellectual portion of the community has at last awakened to the importance of the work in the fields of pure science, that the old prejudice against us who indulge what is called our harmless curiosity is dying out, and that our science is bound to receive a fair share of encouragement and attention in the progress of the modern developments of science and learning.

The distinction that is drawn between pure and applied science is, however, in danger of being broadened and deepened rather than diminished by the recent activity in the foundation of schools and colleges for technical instruction. There are, it is true, several eminent and distinguished persons who recognise the danger and do their best to avoid it, but this fact is not in itself sufficient to justify us in any relaxation of our efforts on behalf of the maintenance and development of those branches of the sciences which are usually supposed to have no direct or technical application.

In the wide field of zoological research there are many subjects now being investigated and discussed which, at present, seem to us to have but a remote bearing upon any practical problem of industry or medicine. Of all these subjects there are two which have excited during the past ten years extraordinary interest, and are from many points of view subjects of greatest possible importance. I refer to the subject of the natural variations of animals and plants, and the problem of the hereditary transmission of characters from generation to generation.

At present there appears to be some doubt whether the workers in these subjects are really agreed as to the general propositions of the problems, the definitions of the terms employed, and the standard of proof that is requisite in each step of progress. It is true that in most, if not in all, biological problems we are at the disadvantage of being unable to define or measure anything with the same mathematical accuracy that our friends, the chemists and physicists, are accustomed to. We cannot say for example that the chela of a particular species of crab is so many millimètres in length, in the manner the chemist determines the atomic weight of a new metal, as the length of the chela is found to vary within a certain range in all species that have been investigated; nor can we define such common expressions as a species, a variation, or even a cell with the same conciseness as a physicist defines the ohm, the volt, specific gravity, or the mechanical equivalent of heat. As a consequence it is not surprising that when our problems have been studied and a solution reached the resultant 'laws' exhibit so many exceptions that they are really not worthy to be called 'laws' at all. We may see the truth, but we see it as through a glass, darkly.

There is perhaps no word in the whole of our vocabulary which is used in so many different senses as the word 'variation,' and yet when it is used an attempt is only rarely made to define the sense in which it is employed.

When we study the adult progeny of a single pair of parents we notice that they differ from one another as regards any one particular character within a certain range. Thus the eight children of a single pair of human parents may vary in weight from, say, 130 lbs. to 200 lbs., and we may find that the average weight of the eight children is approximately the same as the average weight of the two parents. If parents and children were all of exactly the same weight—an impossible supposition—it would be said that they exhibited no variation in this respect, but, as they always do vary in weight, it is said that they exhibit

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'variations' in weight. Now, such variations may be due partly to differences in the muscular training, the nourishment, the general health, and other post-natal causes; but it is assumed, and there are doubtless good reasons for the assumption, that if all these post-natal influences had been equal throughout life there would still remain variations in weight of lesser amplitude than is usual, but nevertheless substantial.

The variation of the adult in weight, therefore, is a compound quantity, partly due to the influence of external conditions upon the growing body, and partly due to a quality or character present at birth and usually supposed to be inherited with the germ-plasm from one or both parents. The former may be called the artificial part of the variation, or for brevity the artificial variation, and the latter the natural or inherited variation. In the character of weight in human beings there can be no doubt that artificial variation is predominant, the character being a very fluctuating one and liable to profound modification in the varying vicissitudes of civilised human life.

In the character of stature the artificial variation is probably much less predominant. The children of tall parents grow into tall men and women, however handicapped in early life by ill-health or insufficient nourishment, and the children of short parents remain short in adult life, however healthy and well fed in their youth. Nevertheless, he would be a bold man who would assert that the character of stature is uninfluenced by the environment, and that the short people would not have been taller had the conditions of their life in childhood been more favourable, or the tall people shorter if the conditions in their early life had been less favourable.

Finally, we have, in the colour of the iris, the shape of the ear, and the size of the teeth, characters which are usually considered to be unmodified by post-natal conditions, or at least so slightly modified by them that the differences observed in them may be regarded as almost pure natural variations. Now, if we turn our attention to characters such as weight, which we feel certain are influenced very profoundly by the environment, we might be tempted to exaggerate the importance of the environment in moulding or forming the characteristic features of the adult organism, as, in the opinion of many authorities, Lamarck did, and many of his followers are still doing. If, on the other hand, we confine our attention to such characters as the colour of the iris or the shape of the ear, we might be tempted to under-estimate the influence of the environment.

This brings us to the important question whether the characters of the adult that are due to the influence of the environment, and that part or degree of any character which is more or less modified by the conditions of the earlier stages of life are or are not transmitted by parents to their offspring. Time will not permit me to discuss this difficult problem here. Rightly or wrongly, I agree with those who maintain that acquired characters are not inherited, and I intend to assume for the purpose of the argument that follows that they are not inherited. I will also assume, and I must say that the facts seem to be conclusive in favour of this assumption, that the characters which are usually supposed not to be influenced, or to be only slightly influenced by, the environment are capable of transmission by heredity.

We have, then, in most variations a part that can be transmitted and a part that cannot be transmitted by heredity from parents to offspring, and we find in every plant and animal an enormous difference in the proportions of these two parts in different organs. It is not difficult to see the general reasons for these differences. It is clearly important that some organs should be plastic—*i.e.* capable of changing in form and size to meet the varying changes in the environment, and that others should remain relatively constant in spite of changes in the environment. Thus the shape and size of the branches of an oak in a plantation will vary enormously, according to the light and space they have for their development, whereas the anthers, the pistils and fruit, will be relatively constant in form and colour. It is clearly important for a chamæleon that the colour of its skin should vary according to the colour of its environment; but it is none the less important that the shape and muscular organisation of its tongue should remain relatively constant throughout life.

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An essential point, however, for us to consider is whether there are any characters in animals or plants upon which the environment exercises no influence at all or exercises such a slight influence that it may be safely neglected. The method to adopt in order to settle this point would be to compare at a definite period of their lives the statistics of variation in a family or population which has been brought up under identical circumstances with a similar family or population at the same period of life which has been brought up under differing circumstances. If this were done we could determine with considerable accuracy the proportion of the variation of any character of the individuals that is due to the environment and that which is natural and inherited.

Unfortunately it is impossible to bring up a population under identical circumstances. If we take, for example, the individuals of a single hive of bees, which have the same parents, pass through the early stages of their development in cells which are almost identical in size and are regularly fed by the workers during the whole of their larval life, there is still a considerable probability that the individuals do not have a treatment which can, with any pretence to accuracy, be called identical. The food that is collected by the worker-bees frequently comes from varied sources or from flowers in different stages of their growth, and it is impossible to believe therefore that it has always identical nutritive properties; the larvæ are not of the same age, and seasonal changes may affect the larvæ differently, some being checked in the early stages of their development more than others.

But even if we could, with justice, assume that the conditions of life for the individual bees in a hive are identical from the time of hatching up to the time when the adult characters are assumed, there still remain two sets of variable conditions which must affect the development independently of the influences brought by the two parents in the germ-plasms.

In the egg of the bee there is a considerable quantity of yolk, and this yolk is the food material upon which the embryo is nourished throughout the earlier stages of its development. There is no evidence that the yolk in the eggs of this or of any other animal is constant either in quality or quantity. On the other hand, the extraordinary variations or abnormalities, as they are usually termed, which the embryologist meets with in the segmentation of the egg suggest that there are considerable differences in these respects between the eggs laid by a single parent in a single act of oviposition. Moreover, the manner in which the young eggs of the insects are nourished in the tubular oviduct before they are ready for fertilisation gives very little support to the view that the amount of yolk deposited in each egg is identical.

The second consideration under this heading is possibly of even greater importance. Vernon [1] has shown that the size and other characters of echinoderm larvæ vary very considerably according to the freshness or staleness of the conjugating ova and spermatozoa. For example, he found that when the fresh spermatozoa of Strongylocentrotus fertilised the eggs which had been kept eighteen hours of the same animal, the larvæ differed from the normal larvæ, −17·6 in body length and −15 per cent. in arm length, and when the fresh eggs are fertilised by spermatozoa which had been kept eighteen hours the resulting larvæ differed from the normal by +11 per cent. in body length and by −32·8 per cent. in arm length.

This consideration is practically eliminated in the case of the worker-bees by parthenogenesis, but it cannot be set aside in the case of the drones nor in the cases of the broods of other animals which do not exhibit the phenomenon of parthenogenesis. A comparison of the curve of variation of some character, common to both, in drones and worker-bees from one hive would perhaps throw some light on the general importance of this character.

Before leaving this part of the subject, I must call attention to two results bearing upon it, obtained by De Vries in his botanical investigations, and related by him in his very important work entitled 'Die Mutationstheorie.' This ob-

[1] H. M. Vernon: 'The Relations between the Hybrid and Parent-forms of Echinoid Larvæ.' *Phil. Trans.* 1898, B. p. 465.

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server found that the younger the seedling is the greater is the influence of external circumstances upon its adult characters, and in the second place that an even greater influence is exerted upon the characters of a plant by the external circumstances affecting the mother-plant. If these results hold good for animals as they do for plants, we should expect to find, then, that the external circumstances affecting the mother at the time she is maturing the eggs in her ovaries and the external circumstances affecting the embryo before and during the larval period are of far greater importance in affecting the curve of variation of the adults than are the external circumstances affecting the young in their period of adolescence. We must come to the conclusion, from these considerations, that the general variability of a brood or progeny of a single pair of parents must be very largely the effect of the varying conditions affecting the gametes from the earliest stages of their genesis in the gonophore, the fertilised ovum, and the early stages of development. We find, however, as I have already pointed out, that some characters are much more influenced by external circumstances than others. Weight and stature in human beings, for example, are probably much more influenced than the colour of the iris or the shape of the fingers. We may, indeed, recognise two kinds of characters, connected, of course, by a complete series of intermediate links, which may be called, for convenience sake, plastic characters and rigid characters.

Now, in some animals, the characters that are rigid are much more numerous than they are in others. For example, adult salmon or perch are much more variable in size and weight than adult herrings or mackerel; some species of butterflies are much more variable in the colour and pattern of their wings than other species; some species of birds are much more variable in their plumage than others are. Several other examples could be chosen to illustrate this point from the higher groups of animals; but I wish particularly to call your attention to several instances found in the Cœlenterata, because it was the special study of this group of animals that led to the train of thought I have ventured to put before you.

In all the sedentary forms of Cœlenterates the mouth is surrounded by a circlet of tentacles. These organs are used for catching and paralysing the prey and passing it to the mouth to be swallowed. They are also very delicate, and indeed the only specialised organs of sense performing a function similar to that of the feelers or antennæ of Arthropoda. There can be no exaggeration in saying, therefore, that they are of the utmost importance to the animal. In some groups of Cœlenterata, however, we find that they are fixed in number, but in others that they are variable.

In the Alcyonaria, for example, the number of tentacles of the adult polyp is eight. I have examined many thousands of polyps belonging to the suborders Stolonifera, Alcyonacea, Gorgonacea, and Pennatulacea, and I have not found a single example of an adult polyp with either more or less than eight tentacles. This is a character, then, which is remarkably well fixed in the Alcyonaria. It does not fluctuate at all. The tentacles of the Hydrozoa, and of many of the Zoantharia, on the other hand, fluctuate considerably in number. In some forms, such as Tubularia among the Hydroids, and Actinia among the Zoantharia, the number of tentacles is considerable, and it is not, perhaps, surprising to find variations in their number. But in many cases, when the number of tentacles is small, there is also frequent variation. In *Hydra viridis*, for example, the number of the tentacles is 6, 7, or 8, and more rarely 5 or 9.

Again, in the Alcyonaria, the number of mesenteries of the adult polyp is always eight; never more and never less.

In the Zoantharia, on the other hand, the number varies not only in different sub-orders and families, but even in different individuals of the same species from a single locality. Parker found, for example, that the number of non-directive mesenteries in the sea-anemone *Metridium marginatum*, collected at Newport, R.I., varied from four to ten pairs in those forms with the normal number (2) of directive mesenteries, and that there were further variations in the number of non-directive mesenteries in those forms with an abnormal number of directive mesenteries. In fact, of the 131 adult specimens collected, only 40 or about 33 per cent. exhibited the arrangement of mesenteries which is regarded as normal

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for the species. On the other hand, Clubb found that of the specimens of another common sea-anemone, *Actinia equina*, only 4·24 per cent. showed variations from the normal mesenterial arrangement for the species. We have then, in these examples, a set of organs which are very variable in one genus (Metridium), much less variable in another (Actinia), and perfectly fixed or rigid in another series of genera (the Alcyonaria).

Passing on, now, to the character 'shape.' Not many years ago the systematic zoologists, who directed their attention to the sedentary Cœlenterates, based their specific diagnoses very largely on the shape of the colonies. Thus we have introduced such names as *Millepora alcicornis*, *M. ramosa*, *M. plicata*, *Madrepora cervicornis*, *M. prolifera*, *M. palmata*, *Alcyonium digitatum*, *A. palmatum*, &c. &c. Zoologists are now agreed, however, that the shape of these colonies is so variable that in most genera it is of very little value for the separation of species. In fact, I have elsewhere given reasons for holding the view that the widely distributed and very variable genus Millepora is represented by only one true species. But what is true for most sedentary Cœlenterates is not true for all colonial Cœlenterates. In most of the genera and species of Pennatulida, for instance, the shape of any one individual of a species is almost identical with that of any other. A *Funiculina quadrangularis*, from the west coast of Scotland, is similar in shape to one of the same species from the coast of Norway. A *Pennatula murrayi*, from the reefs of Funafuti, is similar in shape to one from Ceram. In other words, the character 'shape' is extremely plastic in Millepora and Madrepora, but very slightly plastic or almost rigid in Pennatula and Funiculina.

This difference in the plasticity of the character 'shape' in Millepora and the Pennatulids must be associated with the fact that the young Millepora colony is unable to move from the spot where the larva settles, whereas the Pennatulid is capable of moving from place to place throughout life. The Millepora colony must either accommodate itself to the environment in which it begins life or perish, but the young Pennatulid can, within certain limits, travel to the environment that suits itself.

The shape of a growing coral or sedentary Alcyonarian on a reef must accommodate itself to the depth of water, the position of neighbouring zoophytes to itself, the direction of the tides, and other influences; and such a power of accommodation is essential for the species in the struggle for existence on the coral reef. But in the case of the Pennatulid, the natural or normal shape is adapted to a less variable series of environmental conditions, and it has sufficient power of movement to shift itself into localities where the environment is suitable for it. In other words, the power of movement is associated with a loss of plasticity of the character 'shape.'

But the growth of corals may be affected in other ways. A great many of these forms of life harbour a small fauna of epizoic crustacea, mollusca, and worms, and the ramification or surface is often affected by these in a remarkable way. I have elsewhere pointed out that the character of certain specimens of Millepora, which is known as verrucose, is due to a modification of the growth round epizoic barnacles. Semper has shown that the curious cage-like growths seen on the branches of Seriatopora and Pocillopora are galls produced by the action of certain species of crabs. In a recent paper I have also given reasons for believing that the tubular character of the stem and some of the branches of the genus Solenocaulon is due to the action of certain crustacea belonging to the family Alpheidæ, and that when these Alpheids are not present the form with a solid stem hitherto known as the genus Leucoella is produced.

But whilst some genera of corals and Alcyonaria are plastic in this way, others are not. These coral galls may be found on the Milleporas and Madreporas of a certain portion of a reef and be absent from all the other genera of neighbouring corals. The crab-galls that are found so commonly and in such abundance upon Pocilloporas and Seriatoporas in certain parts of the Pacific and elsewhere are found only in cases of extreme rarity in other corals.

Many other cases could be given to show that in some genera the cœnenchym

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is remarkably plastic or accommodating to these epizoites, whereas in others it is resistent and rigid.

The size and shape of the spicules have been taken as characters for the determination of the species of Alcyonaria. It is true that in some species the spicules are remarkably constant in size and shape, but in others they are extremely variable. The remarkable torch-like spicules of the cœnenchym of *Eunicella papillosa*, the club-shaped spicules of Acrophytum, and the needle-shaped spicules of many species of Pennatulids are remarkably constant in size and shape, but in Sarcophytum, the new genus Sclerophytum, Siphonogorgia, Spongodes, and a great many others, the size and shape of the spicules are extracrdinarily variable. In the matter of colour, too, we find the same thing. The genera Tubipora and Heliopora are widely distributed in the shallow waters of the tropical seas and are very variable in many of their characters, and yet there is not a single specimen of Tubipora known that is not red, nor a single specimen of Heliopora that is not blue. The same may be said for several other species. On the other hand, many species of Alcyonaria are extremely variable in colour. Thus, *Muricea chamæleon* is, according to Von Koch, sometimes yellow, sometimes red, and in some cases specimens show both red and yellow branches. The specimens of *Melitodes dichotoma* in Cape waters are sometimes red and sometimes yellow. In a small species of Melitodes from the Maldive Archipelago there is a very remarkable degree of variation in colour both in the nodes and internodes, the details of which I have briefly described in vol. ii. of Mr. Gardiner's Results. In the genus Chironephthya, also from the same Archipelago, the variations in colour are very remarkable, the spicules of the general cœnenchym showing various shades of red, pink, yellow, and orange, and the crown and points purple, yellow, and orange colours which sometimes agree, but usually do not agree, with the general colour of the cœnenchym. The variability of the genus is particularly interesting, as in Siphonogorgia, the genus which comes nearest to it, and is, in fact, difficult to separate from it, the colour of the cœnenchym is almost invariably red.

To summarise this knowledge of variability in the Cœlenterata we may say that we find either extreme plasticity or remarkable rigidity in many of their most important characters. Such important and essential organs as the tentacles, stomodæum, mesenteries, &c., are in some groups very variable indeed, and in others as stationary or fixed; we find the same with organs such as the spicules of Alcyonaria, which are, so far as we can judge, of less essential importance, and in characters, such as colour, which must be, in the sedentary forms at least, of minor importance.

If we compare this with what we find in the higher groups of animals we observe a great contrast. In fishes, to take an example at random, we may find that in such characters as the size and weight of the adults, there may be great or considerable variability, but in the essential organs, such as the heart, brain, and stomach, there is almost complete rigidity. I do not mean by using the expression 'rigidity' to imply that minor variations in size and shape do not occur, but that major variations, such as a doubling of the stomach, a bifurcation of the cerebral hemispheres or other variations, which it would be considered grotesque to suggest even, do not and cannot occur. But even in minor characters, such as colour, the possible range of variation in a fish is far less than in Cœlenterates. We may find in the mackerel, for example, that individuals differ in the shade and range of the green pigment, but we do not find in any species of fish that some individuals are red, some yellow, some purple, &c.

The contrast in this respect between the Cœlenterate and the fish must be associated with their different degree of complexity of structure. In a complicated organisation such as that of a fish, the brain, heart, and stomach must mutually work together; they must be co-ordinated in form and action. Any profound variation or abnormality of one would interfere with the action of the others and would therefore be incompatible with continued existence. In the Cœlenterate, however, the doubling of the siphonoglyph, the duplication or quadruplication of the mesenteries does not, in some cases, interfere materially with

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the action of the other organs of the body. If we were to alter the size or shape of some part of a simple machine it might be able still to do its work the better or the worse for the change, but if we were to alter the corresponding part of a complicated machine it would probably throw it out of gear and prevent any work being done at all.

From this consideration we gather that in the process of the evolution of the higher forms of life there has been a gradual diminution in the range of variation of the different characters of the body, a gradual diminution of the response of these characters to changes of the environment. Characters which, in the early stages of evolution, were probably plastic become rigid.

The gradual evolution of the power of co-ordinated movement has been undoubtedly accompanied by a loss in the variability of the shape of the body, the gradual evolution of a blood vascular system and nervous system has led to a loss of variability in the alimentary canal with which they are associated. In the majority of cases, however, we are much too ignorant of the facts of the co-ordination of the parts of the body or of the co-ordination of any one part to the environment to be able to frame an hypothesis as to why any one character has become rigid. It is difficult to see the reason why the number of the tentacles and mesenteries in Alcyonian polyps has become fixed at eight, while in other Cœlenterates these characters are so variable, or why the colour of Tubipora is always red, and of Melitodes variable.

The study of species, however, teaches us that, in all cases, except perhaps in some examples of degeneration, the plastic condition of the characters was antecedent to the rigid, that in the earlier stages of evolution the conditions of extreme plasticity and ready response to changing external conditions were necessary for the survival of the species; and that in the later stages, when special adaptations to special circumstances were developed, a certain rigidity or indifference to changing external conditions was equally necessary for its survival.

Now, the study of the various orders of Cœlenterates conveys a very strong impression that the part played by the environment in the production of the variations of the adult is much greater in proportion than it is in the higher groups of animals. It is true that direct proof of this is wanting. Such a direct proof can only be obtained by experiments in rearing and breeding under varying conditions, and there are at present many serious difficulties to overcome before experiments of this nature can be satisfactorily made.

Nevertheless, the circumstantial evidence in favour of the truth of this impression is, to my mind, so strong that we are justified in considering its bearing upon the general question. It is quite impossible for me on this occasion to set before you at all adequately the general nature of this circumstantial evidence. To do so would involve statements concerning the actual variations of a large number of species already observed in one locality and in several widely distributed localities, with a discussion of the possible direct influence of the conditions of such localities, so far as they are known, upon each of the principal variations. Such statements would necessarily be of such a special and technical kind that, even if time permitted me to make them, they would not be suitable for an Address of this character. I may be permitted to say, however, that I am collecting and preparing the evidence for publication on this point at a later date. There can be no doubt, however, from the evidence I have already submitted to you in part, that some species are far more influenced by changes in the environment, or, to simplify the expression, are far more plastic than others; and we may conclude that in the evolution of other groups of animals the earlier forms were far more plastic than their modern descendants. In the earlier stages of evolution there must have been in the first instance a lessening of the power of change in structure according to change of environment. The fixity or rigidity of certain characters thus produced enabled a more elaborate co-ordination both in form and action to occur between one set of organs and another. It permitted a further localisation and specialisation of functions, or, in other words, further differentiation of the animal tissues.

Accompanying this differentiation there was a loss in the power of regeneration

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As Trembley showed many years ago, a Hydra can be cut into many pieces, and each by the regeneration of the parts that are missing will give rise to a complete individual. The Earthworm can, when cut in half, regenerate a new tail but not a new head region. An Arthropod dies when cut in half, but has the power of regenerating new appendages in place of those that are lost. But in Vertebrates there is very little power of regenerating new appendages, and the general powers of regenerating new parts are reduced to a minimum.

Now, whether the loss in the plasticity of characters was the cause of the loss in the power of regeneration of lost parts, or the loss in the powers of regeneration was the cause of the loss of plasticity, is a problem upon which I do not feel we are competent to express a definite opinion; but that the two series of phenomena are intimately associated is, I believe, a generalisation that is worth a good deal of further thought and study.

In Vertebrates, however, although the power of regeneration of lost parts is at a minimum, it is not by any means entirely wanting. The muscles, nerves, epithelia, and other tissues, are able to repair injuries caused by accident and disease. And similarly, although the power of response of various organs to the changes of external conditions in Vertebrates is very much diminished as compared with that in the lower groups of the animal kingdom, it still remains in an appreciable degree. Whether the curves of variation of the so-called fluctuating characters of Vertebrates represent simply or solely the influence of the environment on the organism cannot at present be determined with any degree of certainty; but it appears to me that zoological evidence, confirmed as it is in such a remarkable way by the recent researches of the botanists, points very strongly to the conclusion that the major part of each such curve is, after all, but an expression of the influence of the environment. In venturing to put before you these considerations, I am quite conscious of the vastness and complexity of the problems involved and of the many omissions and imperfections which a short Address of this kind must contain. Not the least of these omissions is that of any reference to the distinction that might be drawn between continuous and discontinuous variations in the simpler forms of life. This is a matter, however, which involves so many interesting and important questions that I have felt it to be beyond the scope of my Address to-day.

We are still in need of further systematic knowledge of the widely distributed species of Cœlenterates; we want to be able to form a more definite opinion than we can at present upon the value of specific distinctions, and we need still further observations and descriptions of the phenomena of irregular facies, abnormal growths, and meristic variations. But more important still is the need of further researches in the field of experimental morphology.

When we have accumulated further knowledge on these lines in a group of animals such as the Cœlenterata, of relative simple organisation, we shall be in a better position than we are now to deal with the problems of heredity and variation in the far more complicated groups of Arthropoda and Vertebrates.

THURSDAY, SEPTEMBER 10.

The following Papers and Reports were read:—

1. *Some Results on the Morphology and Development of Recent and Fossil Corals.*[1] *By* J. E. DUERDEN, *Ph.D., A.R.C.Sc. (Lond.)*

The paper gave a brief account of the results obtained from a morphological study of the polyps of over thirty species of West Indian corals collected by the author while Curator of the Museum, Jamaica; also a preliminary note upon the relationships of the extinct Tetracoralla to living Zoanthids.

[1] Has appeared in *Mem. of Nat. Acad. of Sciences*, Washington, vol. viii.

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Decalcification of the coral stocks has revealed the general occurrence of *boring filamentous algæ* of both green and red species. Their corrosive activity was shown to result in the ultimate destruction of coral masses, and has an important bearing upon theories of the disappearance of coral rock. The *colours* of West Indian living polyps are mainly due to the presence within the endoderm of symbiotic yellow cells—*zooxanthellæ*: this colour may be modified by pigment cells, accumulations of pigment granules, or superficial deposits.

The *column-wall* never exhibits more than a feeble diffuse endodermal sphincter muscle, and in most species the wall can overfold the tentacles and disc. The *tentacles* are mostly knobbed and in close alternating hexameral cycles, but in some forms they are widely apart. The *stomodæum* is without true siphonoglyphs or gonidial grooves; in some the walls are deeply ridged and grooved all round. The *mesenteries* in genera reproducing by budding conform to the cyclic hexameral plan, while this is altogether departed from in forms increasing by fission. The *mesenterial filaments* are simple, never trilobed as in most Actinians; they can be extruded through any part of the polypal wall along with the mesentery to which they are attached. The *skeleton* or *corallum* is an ectoplastic formation laid down within a mesoglœa-like matrix.

Asexual reproduction is by gemmation and fissiparity. In gemmation each new polyp reproduces all the essential features of the larval polyp; in fission no new individuals are produced, the original polyp merely becomes more and more complex and multioral. The enlarged polyps sometimes met with in a state of fission on gemmiferous colonies are shown to represent a specialised form of reproduction termed *fissiparous gemmation*.

Coral polyps are hermaphrodite, but protogyny and protandry seem to occur. The narrow aboral pole of the larva is usually provided with a special nervous development which seems to represent a *larval sense organ*. The primary six pairs of mesenteries (*protocnemes*) arise as bilateral pairs in a succession which is apparently the same in all species; the six pairs constituting the secondary cycle arise bilaterally as unilateral pairs in a dorso-ventral sequence; the twelve pairs forming the tertiary cycle also appear as unilateral pairs in a bilateral manner from the dorsal to the ventral aspect, but in a two-fold succession.

The studies so far conducted on the *Tetracoralla* or *Rugosa* indicate that the primary septal plan is hexameral. The metasepta appear as successive bilateral pairs from a single region within only four of the six exocœlic chambers, the corallite retaining in the adult a bilateral symmetry, not the multicyclic radial condition. The septal development is such as would be followed in polyps with a mesenterial growth similar to that in recent Zoanthids, except that here additional mesenteries arise within only the two ventral exocœlic chambers.

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2. *The Coral Formations of Zanzibar and East Africa.*

By CYRIL CROSSLAND.

Although the land fauna of Zanzibar and East Africa is already well known, very little attention had been paid to that of the sea until Sir Charles Eliot, K.C.M.G., was appointed H.M. Consul-General at Zanzibar, and Commissioner for British East Africa, when he generously provided for the author to accompany him.

The island of Zanzibar is 60 miles in length by 20 in breadth. The outline of the east coast is very regular, its only prominent features being an outlying reef, called Mnemba, in the north, and Chuaka Bay at about the middle of its length. The whole extreme part of the island is composed of coral limestone or 'rag,' low and deeply undermined cliffs which form the greater part of the east coast and of Pemba and the mainland. Below these is a very regular fringing reef from 1 to 3 miles wide, upon the edge of which the surf breaks, leaving a sheltered boat channel along the shore. Beyond the edge of the reef the depth of the water drops almost at once 10 or more fathoms. The larger features of the reef are described in previous accounts as being of the usual kind, and due to the

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continuous growth of corals and nullipores. When examined in detail their structure negatives this conclusion, and shows them to have been carved out by the sea from the dead mass of crystalline coral limestone whose upheaval formed the island of Zanzibar and the adjacent coasts of the mainland. Growing corals are almost totally absent from the reef edge, and nullipores do no more than thinly cover at most half its surface. Further, stones of exactly the properties of the rock of the cliffs occur on the reef edge, and their presence in this situation is inexplicable, except by the supposition that they are the hardest remnants of the mass of rock removed by the sea during the formation of the reefs.

In a few places corals and nullipores flourish in the boat channel either as cylinders of Porites or as irregular blocks formed by the co-operation of several coral genera with a vigorous growth of nullipores, the appearance of the whole block being wonderfully rich and beautiful. In one place the growth of these has continued until their coalescence has produced a continuous surface in appearance like that of the old reef rock, but distinguishable from that by its softness and appearance when broken.

The island of Pemba is very similar in structure to that of Zanzibar, and it has along its eastern coast a fringing reef, but very much narrower, and its boat channel is rudimentary. The reef edge is similar to that of Zanzibar, except in its flora and fauna, which are strikingly different. Instead of the areas being covered by brown filamentous seaweeds, there is on the Pemba reef edge a vigorous growth of nullipores which cover every available space. Stunted corals, Alcyonaria of various genera are also abundant. Even if nothing is being added to the mass of the reef by these organisms, their presence affords a perfect protection from wave action to the underlying rock.

The theory of the origin of these reefs by the erosion and solution of elevated coralline limestone is corroborated by the state of the shore where it is sheltered from the surf by the outlying Mnemba reef. The definite reef form is lost, the shore not only becoming narrow, but consisting of irregular patches of sand and rock as in the shores of temperate seas.

The Mnemba reef itself bears a proportionately tiny sand islet, interesting as having been in the past a rendezvous for pirates, as evidenced by a most carefully built well, every stone of which must have been imported from the reef edge three miles away or from Zanzibar. It is quite certain that no natives of this district, in which a stone house is a rarity, would ever dream of such exertions as this structure must have required, especially for the water supply of an island now inhabited but temporarily by octopus fishers.

The pear-shaped reef has a raised edge like that of the reefs of Zanzibar along its exposed eastern and southern sides, within which is a succession of pools and channels just passable afoot at low spring tides.

If this reef had been situated in the open ocean, so that with the change of the monsoons every side would be exposed to the surf, it would have a raised edge all round, the centre becoming a shallow lagoon. Thus would be produced a typical atoll formed, not by growth of organisms *in situ*, but by the solvent and eroding action of the sea upon a mass of upheaved long-dead coral limestone.

Other reefs which have assumed the atoll form by the action of the same forces are found in every stage of formation in the immediate neighbourhood of Zanzibar town and elsewhere. The first stage, that of an island of rock standing on a flat much larger than itself, is exemplified by Prison Island. The original purpose of the building upon this is explained by the name, but the prisoners petitioned so earnestly against their removal to the island, lest they should die of cold, that it was never used for its original purpose, and has become one of the segregation houses of the quarantine station. Obviously a continuation of this process of erosion will result in the total removal of the island, leaving a rock flat level with the surface of the water at low spring tides. The edges of this are protected from further destruction by the growth upon them of organisms, including in many of these cases vigorously-growing corals. The central parts are, however, removed by solution, forming a miniature lagoon as shown in the charts exhibited.

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The island of Pemba possesses a barrier of reefs and limestone islands off its west coast, inside which are long bays which penetrate into the heart of the island, and were famous in the days of the slave trade as secure hiding-places for Arab dhows from our cruisers' boats. Along the mainland coast is a succession of reefs and islets, forming a continuation of the barrier system of which the island of Zanzibar is a swollen portion. The channel portion between it and the mainland, though much narrower than that of Zanzibar, is like it in its depth of from 15 to 30 fathoms. At Chale Point, and again to the north of Mombasa, this barrier becomes curiously regular and narrow, almost like an artificial breakwater. But here, as elsewhere, coral is quite absent, the reef being formed of elevated limestone. The conclusions reached are summarised as follows:—

1. There are here no reefs due to growth of corals and nullipores *in situ*.
2. There have been, in geologically recent times, great growing reefs, the upheaval and crystallisation of which have formed the rock of the whole coast and outlying islands and reefs.
3. That all the forms characteristic of growing coral reefs have been carved out of this upheaved limestone by the eroding and solvent action of the sea.

Examples: Fringing reefs, east coasts of Zanzibar and Pemba. Barriers, off the mainland and west coast of Pemba. Atolls, Mnemba and certain reefs from Zanzibar Channel and elsewhere.

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3. *Notes on the Coral Reefs of the Indian Ocean.*

By J. Stanley Gardiner, *M.A.*

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4. *Septal Sequence in the Coral Siderastræa.*

By J. E. Duerden, *Ph.D., A.R.C.Sc. (Lond.)*

The six members of the first cycle appear simultaneously within the entocœles of the first cycle of mesenteries. Shortly after six septa appear in a dorso-ventral manner within the six primary exocœles; later they become bifurcated peripherally, either by direct extension of the original septum or by the production of separate nodules, which afterwards fuse.

The second cycle of mesenteries having appeared, new septa arise peripherally within their entocœles in the same radii as the six primary exosepta. Later these second-cycle entosepta fuse with the original primary exosepta, and become the secondary septa of the mature corallite, while the bifurcations of the six primary exosepta now form the third cycle of twelve exosepta. The exosepta of the third cycle afterwards bifurcate, and on their appearance the third-cycle mesenteries are included by them. New septa then arise within the entocœles of the third-cycle mesenteries, fuse with the third-cycle exosepta in the same radii, and constitute the adult third-cycle septa. The twenty-four exosepta of the fourth cycle are formed from the bifurcations of the temporary third-cycle septa.

Exosepta are thus present at each cyclic stage in the growth of the corallite, alternating in position and corresponding in number with the sum of the entosepta. They never become entosepta, but always constitute the outermost cycle of shorter septa; only the entosepta have any ordinal significance. The developmental relationships between the entosepta and exosepta are closely comparable with those first established by Lacaze-Duthiers for the entotentacles and exotentacles of actinians. With the exception of the first, the members of each septal cycle follow a dorso-ventral succession, display a bilateral symmetry for some time, and ultimately assume an approximate radial plan.

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5. *Polymorphism in the Pennatulida.*[1]
By Professor Sydney J. Hickson, *F.R.S.*

Pennatula Murrayi was obtained by H.M.S. 'Challenger' off the coast of Ceram, and was first described by Kölliker. Recently Moroff has described some specimens of the same species from Japanese waters.

The Dutch Siboga expedition obtained several fine specimens in the Moluccas which have been placed in my hands for examination.

A characteristic feature of the species, recognised by Kölliker and Moroff, is the presence of a single large siphonozooid at the base of each pinnule, in addition to numerous other siphonozooids of a smaller size on the dorsal and lateral sides of the rachis.

The large siphonozooids can be easily recognised with the naked eye, and are distinguished in well-preserved specimens by their open mouths and by a single pair of papilliform verrucæ hanging over each of them.

On further examination the large siphonozooids are found to differ from the ordinary ones in the large size of the stomodæum, the rudimentary condition of the siphonoglyph, and the extraordinary development of the muscles on the lateral mesenteries.

There can be little doubt that these large siphonozooids are adapted to some special function, and should be regarded as a distinct form or type of zooid in the colony. Nothing similar to them has hitherto been described in the Pennatulida.

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6. *The Assimilation and Distribution of Nutriment in* Alcyonium digitatum. *By* Edith M. Pratt, *M.Sc.*

When working out the comparative anatomy and histology of several genera of the *Alcyonidæ* certain interesting features presented themselves in those portions of the zooids which are apparently devoted to the digestive function. I was therefore led to a study of the British genus *Alcyonium* in the living as well as the preserved condition, and subjected numerous specimens of the species *digitatum* to a series of feeding experiments with the view of ascertaining (1) the nature of the food supply, (2) the manner and course of digestion, and (3) the subsequent distribution of nutriment.

The principal results of these experiments, which were carried out at the Biological Station of Port Erin, may be summarised as follows:—

1. *The Food of* Alcyonium.—(*a*) The zooids of freshly taken colonies of *Alcyonium* only in rare cases contained food material, which consisted of fragments of minute crustacea. (*b*) Apparently healthy and hungry colonies refused, with one or two exceptions, to feed on ova of the cod, plaice, whiting, flounder, and extremely small embryos of the crab 'Galathea.' (*c*) When the same colonies were placed in a concentrated tow-netting containing Nauplii, Copepods, and Daphnids, they fed on these small crustacea with great avidity. (*d*) Similar colonies also readily fed on the pounded flesh of plaice, whiting, and cod.

From these experiments one would conclude that the coral exercises considerable choice in the selection of food material.

2. *Course and Digestion of Food.*—By staining the pounded flesh of fish with borax carmine the course of the food could be very easily observed through the transparent body-walls of the expanded zooids.

The food is captured by the tentacles. If living it is killed by the poisoned threads of the nematocysts, which are extremely numerous on the pinnate tentacles. It is then transferred to the mouth by the tentacles and swallowed. In passing through the stomodæum it receives the somewhat scanty secretion from the gland cells lining its walls. It then passes into the cœlenteric cavity, where it is enfolded and squeezed by the ventral and lateral mesenterial filaments, which also pour on to the food a copious secretion from their gland cells, which are

[1] Will be published *in extenso* in the Reports of the Siboga expedition.

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identical in appearance with those of the stomodæum. With the exception of the genus Xenia the occurrence of gland cells in the stomodæum has not hitherto been recorded in any other member of the family. I have, however, observed them in every other genus which I have had the opportunity of examining; it is therefore very probable that they occur throughout the family.

The secretion from the gland cells, combined with the pressure exerted by the mesenterial filaments, breaks up the food into minute particles, which are ingested and subsequently digested by the *amœboid endoderm cells* of the ventral and lateral mesenterial filaments. Particles of food which escape the filaments are apparently taken up by the amœboid endoderm cells lining the cœlentron and canals.

3. *Distribution of Nutriment.*—I have observed the stellate cells, which compose the so-called 'mesoglœal nerve-plexus,' to withdraw and thrust out the processes which have been called 'nerve-fibrils,' and by this means change their shape and position. *These cells therefore are amœboid.*

After squirting clouds of finely powdered carmine about the extended tentacles of expanded zooids for several days, particles of carmine were observed to be present: (1) in the amœboid endoderm cells of the ventral and lateral mesenterial filaments and cœlentron; (2) in the amœboid cells of the endodermal canals; (3) in the stellate cells comprising the so-called 'nerve-plexus,' which I have observed to be amœboid.

The amœboid endoderm cells containing carmine particles were observed to thrust out processes into the mesoglœa and to assume a condition identical in appearance with the stellate cells composing the 'nerve-plexus.'

I would therefore suggest that the distribution of nutriment is effected in the following manner. Certain amœboid endoderm cells loaded with nutriment wander or have wandered into the mesoglœa, where they form an amœboid plexus of cords and strands of cells which extends throughout the colony. The intimate connection between the digestive endoderm cells of the zooids and the plexus is maintained. If we suppose that throughout the plexus the nutritive protoplasm may be transferred from cell to cell—and the presence of carmine particles in the mesoglœal plexus affords substantial evidence for believing this to be the case—then this system of amœboid cells must be regarded as a *nutritive plexus*, and by its means nutriment may be conveyed from the digestive endoderm cells of the zooids to every portion of the colony.

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7. *On the Origin of the Epiphysis in Amphibia as a Bilateral Structure.* By JOHN CAMERON, *M.B.*

In very early embryos of Amphibia (Rana, Bufo, Triton), the epiphysis is found to develop in the form of two small recesses or outgrowths from the roof of the fore-brain, which are placed on either side of the mesial plane. The right recess terminates its existence by blending with the more rapidly developing left recess. This active growth on the part of the latter causes the epiphysial opening to become situated to the left of the mesial plane in the majority of cases. These above observations in the case of the amphibia, correspond in many ways with those of Béraneck, Dendy, Gaskell, and Locy in other vertebrate types. During the later stages of development in amphibia there are distinct evidences of the bilateral origin of the epiphysis; for the portion in relationship to the superior commissure (fibres from which form the nerve-supply of the pineal eye), along with the part distal to this, together correspond to the pineal eye of Hatteria, while the remainder of the proximal portion which communicates with the thalamencephalon, corresponds to the epiphysial stalk of Hatteria. The degenerative condition of the amphibian epiphysis is probably due to this blending together of the right and left primary recesses—the result of this being that they mutually interfere with one another's growth. This observation is supported by the fact that the left epiphysial outgrowth in Hatteria (according to Dendy) remains

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distinct from the one on the right side, and becomes developed into a well-formed pineal eye.

In the lower vertebrate classes the epiphysis is to be recognised as a bilateral and not as a mesial structure, and in addition to this it may be noted that the ancestors of vertebrates probably possessed a pair of parietal eyes (Gaskell and Dendy).

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8. *Final Report of the Committee on the Migration of Birds.*
See Reports, p. 289.

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9. *Report of the Committee on the Occupation of a Table at the Zoological Station at Naples.*—See Reports, p. 282.

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10. *Report of the Committee on the Index Animalium.*
See Reports, p. 288.

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11. *Report of the Committee on the Zoology of the Sandwich Islands.*
See Reports, p. 305.

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12. *Fourth Report of the Committee on Coral Reefs of the Indian Region.*
See Reports, p. 305.

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13. *Interim Report of the Plymouth Marine Laboratory Committee.*

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14. *Report of the Millport Marine Laboratory Committee.*
See Reports, p. 308

Department of Physiology.

The following Reports were read:—

1. *Report of the Committee on the Microchemistry of Cells.*
See Reports, p. 310.

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2. *Report of the Committee on the State of Solution of Proteids.*
See Reports, p. 304.

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3. *Interim Report of the Committee on the Physiological Effects of Peptone.*

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4. *Interim Report of the Committee on the Functions of Visual Purple on the Retina.*

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FRIDAY, SEPTEMBER 11.

After the President had delivered his Address (see p. 673), the following Papers were read:—

1. *The Bionomics of* Convoluta roscoffensis, *with special reference to its Green Cells.*[1] *By* FREDERICK KEEBLE, *M.A., and* F. W. GAMBLE, *D.Sc.*

Convoluta is remarkable for its green cells. Geddes showed that these cells assimilate and form a reserve of starch. V. Graff, failing to find any trace of gut or food in *Convoluta*, concluded that the animal is wholly dependent on the green cells for its food. Geddes' observation that *Convoluta* dies within two days if kept in darkness is also taken as indicating the same dependence of the animal. Haberlandt investigated the histology of the green cells and discussed their origin without coming to any well-founded conclusions, leaving it uncertain whether the green cells enter the animal from without or arise within it.

Our researches deal with the relation between green cell and animal and with the question of the origin of the green cell. We find that *Convoluta* feeds voraciously, taking up diatoms, algæ, spores of various kinds, litmus, indigo, lamp-black, and potato-starch; that *Convoluta* lives for three weeks in darkness without any especial precautions; and that the store of starch is reduced very slowly, not disappearing until after eight days. From these conclusions it would appear that *Convoluta* is less completely dependent on the green cell than was supposed. Nevertheless under certain circumstances the animal digests its own green cells.

With respect to the origin of the green cells Georgevitch has shown that the larvæ of *Convoluta* are colourless, and that they die in two days if kept in filtered water. We show that the earliest stage of the green cell is a colourless or almost colourless cell; that colourless larvæ may be kept in filtered water for upwards of a month; and that when sea-water is added infection follows, whereas when maintained with sufficient precautions in filtered sea-water no infection occurs. We conclude that the green cell is an alga, a stage in the life-history of an organism widely distributed in sea-water; that it makes its way into the body of *Convoluta*, multiplies there, and almost invariably dies with its host. From the characters of the green cell we conclude that it is a hypertrophied zoospore.

Questions of considerable interest still remain, as in all cases of symbiosis. For example, the origin of the proteid food material required by both animal and plant; the question as to whether the animal may avail itself of the carbohydrates of the green cell otherwise than by destroying that cell.

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2. *Note on the Skull of* Grampus griseus *found on the Coast near Galway.* *By* Professor RICHARD J. ANDERSON, *M.D.*

A grampus of considerable size got stranded on the coast near Galway a few years ago. The carcass was lost, but the skull was found last winter; and as this cetacean is far from common in Ireland, a few points with reference to the structure of this fragment may be noted. The skull is much smaller than that of *Globiocephalus melas*, and much less massive, and the sockets for the teeth in the upper jaw are small and inconspicuous. It is evident that the sockets have been filling up for years. The number of teeth in *Grampus griseus* varies from two to six in the lower jaw. They are more numerous in the young mature than in the old, and the upper jaw seems to be edentulous; the teeth are deciduous. A young skull found on the beach, some time ago, which belonged to a small specimen washed ashore, was considered to be that of a *Grampus griseus* (*Rissoanus*) by Professor D'Arcy Thompson, in all probability the offspring of the specimen here noted. The length of the animal was probably about 12 feet. This size corresponds to that of *Rissoanus*. This is borne out by the dental groove, traces of which, as

[1] Will appear in the *Proc. Roy. Soc. London.*

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well as of three tooth-sockets on one side and four on the other, still persist. The pterygoids touch. The premaxillæ show an elongated triangular surface in front of the blow-holes.

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3. *Notes on the Peritoneum in* Meles taxus. *By* Professor Richard J. Anderson, *M.D.*

The peritoneum in a badger examined some time ago presents some points of interest.

The vena cava posterior occupies the usual position behind the level of the anterior end of the right kidney. The vein, however, after receiving the right renal becomes separated from the posterior abdominal wall, and with a simple investment of peritoneum goes forward to the liver.

So marked was this venous cord that the space between it and the abdominal wall was for a moment mistaken for the foramen of Winslow, which, however, was immediately seen lying to the left.

A cord was found on the left side reaching from the kidney to the omentum, and this trabecular band seems to have been generated in a somewhat similar manner to that in which the right one arose.

The question arose here whether the foramen of Winslow may not be aided in forming by the growth of the upper part of the liver, which may induce a separation of the vessels included in the omentum.

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4. *The Skull of* Ursus ornatus. *By* Professor Richard J. Anderson, *M.D.*

The bear of the Cordilleras, *Ursus* (?) *ornatus*, was at one time regarded as an ally of *Ursus malayanus*. The nasal bones in both genera are short, and while the swollen parietal region in *malayanus* suggests a more elevated position, the greater depth of the skull is equally suggestive of a higher type in *Ursus ornatus*. The great crest of the skull in the latter type is not unlike a similar structure in Cebus, a monkey which the greater depth of the skull brings the bear to resemble; and it is necessary to prop the skull by a wedge introduced beneath the occipital in order to display the parts to the best advantage, and to make the skull rest on the inferior margin of the lower jaw. In *Ursus polaris* the skull, it will be remembered, lies flat upon a table.

The plane of the nasal apertures meets the alveolar plane at a high angle. The sagittal ridge, which goes directly back, is placed at an angle of 45° to the plane of the anterior nares. The ridge is parallel to the plane passing through the lower border of the mandible.

The coronoid process is 4¼ inches above the level of the angle of the lower jaw, and the angle is inflected.

The line joining the summit of the occipital bone with the angle of the lower jaw is nearly parallel to the line joining the inter-premaxillary suture to the nasals. The skull is thus rhomboidal (or rhombohedral) in profile.

The summit of the nasals is directly above the first molar. Compared with a Howler monkey the nasal summit was found to be directly above the anterior premolars. The length of the skull is 24 cm., height 14 cm., breadth 16 cm. between the zygomata, and 9 cm. between the most prominent parts of the parietals.

The capacity of the cranial cavity in the skull examined is greater than that of *Ursus americanus*, of *Ursus thibetanus* (*torquatus*), and of an adult lioness. It is, however, less than that of *Ursus malayanus*, and that of *polaris* with a longer skull.

Ornatus seems, therefore, to be a composite type.

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MONDAY, SEPTEMBER 14.

The following Papers were read:—

1. *On the Significance of Progamic Nuclear Divisions.* *By* Professor MARCUS HARTOG.

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2. *Nuclear Changes in the Egg of* Alcyonium. *By* M. D. HILL, *M.A.*

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3. *The Function of Chromatin in Cell Division (Part I. Heterotype).* *By* Professor MARCUS HARTOG.

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4. *Discussion on Fertilisation, in which the following took part:*— Professors HICKSON, FARMER, HARTOG, and Messrs. W. BATESON, M. D. HILL, *and* J. W. JENKINSON.

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5. *On the Tentacles of Suctoria.* *By* Professor MARCUS HARTOG.[1]

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6. *Demonstration of Slides showing Conjugation in* Dendrocometes. *By* Professor S. J. HICKSON, *F.R.S.*

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7. *The Effect of Solutions of Salt and other Substances on the Development of the Frog.* *By* J. W. JENKINSON, *M.A.*

O. Hertwig and others have shown that the course of development of frogs' eggs grown in certain solutions of salt and other substances is abnormal. The abnormalities consist in the formation of a large persistent yolk-plug, due to the failure of the lips of the blastopore to grow over the yolk and in the incomplete closure of the medullary folds.

The following investigation was undertaken in the hope of determining whether the effects observed are due entirely, as has been maintained, to the increase in the osmotic pressure or to the change in the chemical composition of the medium as well.

The eggs were placed in a solution of ·625 per cent. sodium chloride, and in isotonic solutions of cane-sugar, grape-sugar, urea, potassium chloride, and lithium chloride.

During the first two days development was sensibly similar in all the eggs, but slower than in the normal controls. Subsequently, however, while the malformations which were produced were in all cases similar in kind they differed greatly in degree.

In urea the blastopore closed at a later period than usual, but in other respects development was fairly normal. The tadpoles died. In cane-sugar and dextrose the blastopore was late in closing, and the medullary groove remained open, in the latter case widely open. In the chlorides of potassium and lithium the yolk remained almost entirely uncovered, and the embryos died almost before the formation of the medullary folds. In sodium chloride they lived longer; the

[1] Published in the *Archiv für Protistenkunde*, Bd. I. 1902, pp. 372–374.

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medullary folds either remained open, in front only or throughout, or else closed. The yolk-plug was large.

It appears, therefore, that other factors besides the increase in osmotic pressure must be taken into account in explaining the phenomena.

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8. *Some recent Observations on British Reptiles.*

By GERALD LEIGHTON, *M.D., F.R.S.E.*

1. It has long been a matter of dispute and doubt whether the British adder (*Vipera berus*) ever took to the water as a matter of ordinary habit. Most ophiologists denied this, or at any rate had not observed it. Years of observation in English counties had failed to bring forward a single case, but the result of some correspondence indicated that in Scotland the habit was not unusual. Investigations and experiment with adders in the Scottish Highlands proved that in that district adders were in the habit of swimming the streams and rivers, a habit which has become incorporated in some of the folklore of the Highlands.

2. Fatal cases of adder-bite are by no means so rare in Great Britain as most people suppose. One was reported last year, and a few weeks ago there was another in South Wales. Both were in young boys.

3. In addition to the very restricted distribution of the smooth snake (*Coronella austriaca*) in Surrey, Hants, and Dorset, it is known that Berkshire was also a habitat twenty years ago. For years, however, no specimen has been seen in that county, and it was supposed to have become locally extinct. During the present summer it has reappeared, one specimen having been taken near Wellington College. Probably this species is more widely distributed than we know of, its close resemblance to the adder causing it to be destroyed without recognition at the hands of those who encounter it.

4. Associated with the smooth snake in its distribution is the sand lizard (*Lacerta agilis*). This rare lizard is found in the same parts of the counties above mentioned, and is the staple food of the smooth snake. But the sand lizard also occurs in very considerable numbers in the neighbourhood of Southport, and practically nowhere else than the places stated. Here, however, the smooth snake has never been known to occur, and it is curious that this lizard should be so common locally and absent from all other places north of the Thames.

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9. *Notes on the Coloration of Malayan Reptiles.*[1]

By N. ANNANDALE, *B.A.*

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10. *Note on the Walking Fish of the Malay Peninsula.*[1]

By H. C. ROBINSON.

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11. *Exhibition of Convergent Series of Malayan Butterflies.*[1]

By H. C. ROBINSON.

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[1] Will appear in the *Fasciculi Malayenses.*

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TUESDAY, SEPTEMBER 15.

The following Papers were read:—

1. *Note on Pearl-formation in the Ceylon Pearl Oyster.*

By Professor W. A. HERDMAN, *D.Sc., F.R.S., and* JAMES HORNELL.

Professor Herdman and Mr. Hornell have had two cruises of several weeks each amongst the pearl-oyster banks in the Gulf of Manaar, and have had the experience of the three consecutive inspections of March and November 1902 and March 1903, and also the successful fishery of 1903, from which to draw conclusions. Many hundreds of oysters have been examined, and large numbers of pearls have been decalcified. As a result of this work they have come to the conclusion that there are several distinct causes that lead to the production of pearls in the Ceylon pearl 'oyster' (*Margaritifera vulgaris*, Schum.).

1. Some pearls or pearly excrescences on the interior of the shell are due to the irritation caused by *Clione*, *Leucodore*, and other boring animals.

2. Minute grains of sand and other inorganic particles only form the nuclei of pearls under exceptional circumstances. Probably it is only when the shell is injured, *e.g.* by the breaking of the 'ears,' thus enabling sand to get into the interior, that such particles supply the irritation that gives rise to pearl-formation.

3. Many pearls are found in the muscles, especially at the levator and pallial insertions, and these are formed around minute calcareous concretions, the 'calcospherules,' which are produced in the tissues and form centres of irritation.

4. Most of the fine pearls found free in the body of the Ceylon oyster contain the remains of Platyhelminthian parasites, so that the stimulation which leads to the formation of an 'Orient' pearl is, as has been suggested by various writers in the past, due to the presence of a minute parasitic worm. In all cases, whatever its nucleus may be, the pearl, like the nacre, is deposited by an epithelial layer.

These pearls may be conveniently classified as—

I. *Ampullar pearls*, where the nucleus and resulting pearl lie in a pouch, or ampulla, of the ectoderm projecting into the mantle. The others lie in closed sacs.

II. *Muscle-pearls*, formed around calcospherules near the insertions of muscles.

III. *Cyst-pearls*, formed around encysted parasites. The parasite in the case of the majority of the cyst-pearls of Ceylon is the larva of a Cestode which appears to be new, and will be described under the name *Tetrarhynchus unionifactor*. The younger larval stages have been found free-swimming in the Gulf of Manaar and on the gills of the oyster; later stages are common in the liver, mantle, and gills; and a more advanced *Tetrarhynchus* is found in the file fishes, *Balistes mitis* and *B. stellatus*, which feed upon the oysters. The sexually mature Cestode has not yet been found, but we may expect it to occur either in one of the large Elasmobranchs (such as *Trygon uarnak*) which abound on the pearl banks, or possibly in one of the smaller cetaceans, which may also feed upon such fishes as *Balistes*.

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2. *On a Phosphorescence Phenomenon in the Indian Ocean.*

By Professor W. A. HERDMAN, *D.Sc., F.R.S.*

Professor Herdman described how during his recent expedition to Ceylon, as they lay at anchor in the Gulf of Manaar, on March 13, 1902, about 9 P.M., the sea was seen to be dotted with bright phosphorescent lights, of considerable size, singly placed at some distance apart. These for over an hour continued to glow with a pulsating appearance *in harmony*, all shining brightly at the same moment, and then all flickering out together, to reappear simultaneously a few

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seconds later. On going out at once with a net a sample of the plankton was obtained, but it was not certain that any of the pulsating forms had been caught. The gathering contained *Sagitta* (very many), *Appendicularia*, Copepoda, several common species and *Sapphirina sinuicauda*, *Pontella fera*, *Calocalanus pavo*, and some smaller forms, along with half-a-dozen one-inch-long Heteronereids of a reddish-brown colour. The light was thought to be probably due to the last named, and if that is so possibly the periodicity was a result of the epitocous condition, and was accompanied by a simultaneous discharge of genital products. The matter, however, could not be made certain at the time, and the above explanation is only suggested.

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3. *Note on Birds now rare in the British Isles.*
By G. P. Hughes, *F.R.G.S.*

The author gave a brief account of a male and female Bittern shot at the base of Cader Idris last winter, and of a Common Crane he lately saw in the valley of St. John, Isle of Man, species now rare in the British Isles.

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4. *Demonstration of Visual Combination of Complementary Colours.*
By C. A. Greaves, *M.B., LL.B.*

The author showed that the difficulty in visually combining different colour sensations so as to perceive the resultant is overcome in the case of *green + red = grey* by the use of the present halfpenny and penny stamps, stereoscopically superposed, these stamps being identical in design and of good complementary colours.

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5. *The Epithelial Islets of the Pancreas in Teleostei.*
By John Rennie, *D.Sc.*

It has been found that in all the leading divisions of this group there exist in more or less intimate relation to the pancreas epithelial bodies similar to the 'islets' present in higher forms. In a large proportion of cases there is an islet in the mesenteric fold anterior to the spleen, which is of constant occurrence. It is also the largest. As similar constancy has not been made out for the others it has been termed the 'principal islet.' These bodies are an epithelial tissue consisting of masses of very small polyhedral or cylindrical cells well supplied with blood capillaries. In many cases two types of cell are evident within the islet, which may be two distinct tissues or the same tissue in different functional states. A comparative study of their relations to the zymogenous tissue of the pancreas suggests that they are blood glands which have entered into a *secondary* relation to the pancreas. It is likely that they maintain their primitive function as glands possessing an internal secretion.

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6. *On the Echinodermata of the Firth of Clyde and Variation in* Ophiocoma nigra.[1] *By* D. C. McIntosh, *M.A.*

In this paper, which dealt with the Echinodermata of the Clyde area, notes were given on the frequency of the occurrence of the different genera and on some of the most obvious variations exhibited by certain of the species. The daily dredging expeditions of the steam yacht 'Mermaid,' which is run in connection with the West of Scotland Marine Biological Association Station at Millport, afforded one ample opportunity for making the necessary observations.

It was pointed out that while forty-two species are recorded for the Clyde (against at least thirty-five for the Irish Sea), there were actually found during

[1] Published in *Biometrika*, vol. iv.

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the autumn of 1902 thirty-three species, viz. Holothuroidea 8, Crinoidea 1, Asteroidea 11, Ophiuroidea 7, and Echinoidea 6, the most common genus of each of these orders being *Synapta*, *Antedon*, *Asterias*, *Ophiocoma*, and *Echinus*. Note was taken of the very considerable variations in the shape of the test of *Echinus esculentus* and in the number of arms of certain of the Asteroidea.

The remaining part of the paper was taken up with a discussion on the variation of *Ophiocoma nigra* (O. F. Müller), and an account was given of the results obtained from an examination of certain external features of 3,000 specimens of this Brittle-star. An attempt was made by means of diagrams to classify the shape and colour variations of the disc. It was found that the disc tends to become circular in the more fully developed animals, but that it is in general pentagonal and not round. Twenty-four per cent. showed no colour variation, while 64 per cent. had a pentagonal yellowish central disc marking. In 12 per cent. of cases this marking was small and circular. The correlation between arm-length and disc-breadth was worked out by the methods followed in 'Biometrika,' and a table was given showing the number of animals having a certain disc-breadth associated with a certain arm-length. The equation to the 'Line of Regression' of arm-length on disc-breadth was

$$y = 4{\cdot}89623x + 1{\cdot}17469062,$$

and this was shown by means of a diagram to represent very closely the observed facts. The mean disc-breadth and arm-length were respectively 10·106 mm. and 50·656 mm., a relationship which is very noteworthy in view of the important part which the number *five* plays in the arrangement of the organs of the Echinodermata. A 'Polygon of Frequency' based on the disc-breadth was given, and also the curve whose equation is

$$y = 185{\cdot}57\left(1-\frac{x}{9{\cdot}3264}\right)^{12{\cdot}0050} \times \left(1+\frac{x}{20{\cdot}9013}\right)^{28{\cdot}8705}$$

which best fits it. Tables were added showing that ·13 per cent. had more than one madreporic plate, and that out of 3,000 specimens thirteen had an abnormal number of rays, there being one Brittle-star with only four arms and twelve with six arms each.

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7. *Note on the Eggs of the Shanny* (Blennius pholis, *L.*).

By Professor W. C. McIntosh, *M.D.*, *F.R.S.*

In the life-histories of the British food-fishes, published by Dr. Masterman and the author in 1897, it is stated that the eggs of this fish had not hitherto received satisfactory attention. In June of this year an adult female, 4¾ inches in length, was captured with enlarged ovaries. On the morning of June 5 it was found to have discharged a number of golden eggs, each having a faintly pinkish disc for fixing it to stones and other surfaces. As attached to glass, each egg was circular in outline with a distinct hyaline zona, the contents being dull pinkish or pale salmon. This tint was enlivened by a series of bright yellow granules and masses (oil-globules). The egg formed an oblate spheroid, the vertical diameter being ·7630 mm., whilst the transverse diameter ranged from 1·1811 mm. to 1·2192 mm. The breadth of the pale pinkish rim for attachment was about ·3048 mm. Many of the discs had a finished appearance, whilst in others the edge was spongy, with projecting processes. In minute structure the whole is granular. Allusion is made to the observations of Dr. Scharff on the structure of the peculiarly modified ovarian follicle of the shanny and the remarkable hardihood of the fish, which can be kept for a week at least in fresh water. The proportion of males and females is also mentioned. The food of the shanny at St. Andrews largely consists of the stunted small and young mussels, *Balani*, small univalves, such as young Littorinæ and adult Rissoæ, with fragments of limpet.

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Department of Physiology.

1. *A Physiological Theory to Explain the Winter-whitening of Birds and Mammals in Snowy Countries, and the most Striking Points in the Distribution of White in Vertebrates generally.* *By* Captain G. E. H. Barrett-Hamilton.[1]

The subject of the winter-whitening of animals, though of much interest to zoologists, is very imperfectly understood. Most writers are satisfied to believe that the colour change originated somehow under the action of natural selection for the protective purposes of adaptation to environment.

The author finds, however, that the change has a deep physiological significance. There is, for instance, in mammals a definite sequence in which the various parts of the body whiten. This sequence, on the whole, corresponds to the summer accumulation of fat in the panniculus adiposus. Thus the belly, where peripheral fat is thickest, is permanently white, and the rump, often the next thickest area of fat accumulation, is usually the first part to whiten in winter.

Many northern mammals and birds not usually regarded as of this category are lighter in winter than in summer. The white assumed in the former season corresponds to the fat-tracts, and they may be therefore regarded as subject to the same process.

In the northern summer most animals accumulate fat, always in a definite manner as regards the regions where it is deposited. This fat is indicative of deficient oxidisation and sluggish metabolism, and the process of its accumulation is therefore one of atrophy. The fat-accumulation and atrophy is most marked in autumn, at which season metabolism is lowest. Under the onset of winter cold the atrophy may extend to the hairs. Their pigment (as observed by Metchnikoff) is then removed, always, however, first in those parts where peripheral fat is thickest, and atrophy therefore greatest. Should there be a change of coat at this time the new hairs are influenced by the same conditions. In very cold countries they come up white all over the animal; in more temperate regions the parts only where fat is thickest are white.

Although a pigmented hair can thus undergo atrophy and loss of pigment, the author knows of no case where the colour is replaced. Animals once whitened remain so until the spring moult.

These facts apply broadly to birds and mammals, but the variable hare and stoat are those which have been studied especially.

The same law is responsible for much of the distribution of the white colour throughout the vertebrate phylum, wherein the connection between the white colour and the peripheral fat-tracts (thus indicating local atrophy) may be widely traced. Thus domestic animals, nearly all of which are prized most for their power of accumulating fat, exhibit a strong tendency to the development of white patches. In both these and in wild animals the belly, where occurs the principal fat-tract, is the most frequently white part; next follow the rump, neck, and parts of the limbs and of the head.

Marked exceptions are no doubt frequently due to unusual arrangements of the panniculus adiposus. Thus in the badger, a representative of a family in which the back is usually whiter than the belly, a correspondingly exceptional arrangement of the fat-tracts occurs.

The white of the head—the 'blaze' of horses and the facial stripes of the badger, for instance—affects regions, not of fat-accumulation, but where the skin immediately overlies bone and membrane (frontals, nasals, and zygomatic arches), which thus seem to produce an atrophy similar to that caused by underlying fat.

In many animals the hair-atrophy assumes the form, not of whitening, but of baldness. Marine mammals are hairless in proportion to their fatness; fattening cattle lose their hair, while the baldness of man corresponds in position to the 'blaze' of horses, and the bare buttocks of monkeys to the white rumps of other mammals.

[1] Will appear in the *Proceedings of the Royal Irish Academy*.

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Yellow and red frequently follow the same rules of distribution as white. They are well known to be fat-pigments.

The author carefully guards himself against the extension of his theory to all cases where white occurs in vertebrates. It is obvious that not all animals are subject to this atrophy, and there must be other causes for absence of pigment. It seems highly probable from what the author has written that the known unevenness of animal coloration is but the external indication of uneven nutrition in different regions of the body.

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2. *A New Form of Osmometer for Direct Determinations of Osmotic Pressure of Colloids.* *By* Professor BENJAMIN MOORE, *M.A., D.Sc.*

This form of osmometer has been specially designed to avoid leakage and provide a large surface for diffusion compared to the volume of solution employed, so that the influence of crystalloids is made slight and transient. To effect the first purpose the instrument is made in metal in two halves which can be tightly screwed together by a collar, and the two halves are further made up of two shallow cells, to hold the solution and solute, so that the influence of admixed crystalloids is rapidly eliminated by diffusion.

The instrument essentially consists of two flattened circular cells of platinum [1] 5 cm. in diameter and 1 cm. in depth, with flat flanges at their rims which fit into corresponding thick flanged cases of silver-plated brass. The brass cases can be screwed tightly together by a brass collar with a female screw at one edge, which engages with a male screw on one of the brass cases, and a flange on the other edge which catches on the flange of the other brass case.

A diaphragm of platinum bored closely with holes about 3 mm. in diameter is placed between the two cells, and serves to support the membrane of parchment paper which separates them.

The instrument is made pressure-tight by two rings of thin indiarubber sheeting placed on either side of the diaphragm, and when the collar is securely screwed home has in all cases been found free from any trace of leakage.

A platinum tube of about 4 mm. diameter leads, at right angles, from the centre of the back of each cell, and is used to connect up for filling and registering the pressure.

The large surface provided for diffusion compared with the volume of solution assures an early equilibrium of crystalloids. When a 1 per cent. solution of sodium chloride is placed on one side and distilled water on the other, there is no appreciable movement in the attached mercurial monometer, and within twenty-four hours the amount of sodium chloride on the two sides is equal within the limits of experimental error.

The connecting tube on the side of the colloidal solution is joined up by rubber tubing to a T-piece, which is in communication by one arm with a glass funnel and by the other with a mercurial monometer. On the side of the solute (water) the cell is simply joined by rubber tubing to a funnel.

In using the apparatus the connections are first filled with the respective fluids and temporarily clipped off, then the cells are filled in turn and joined up, all air being expelled by pressure upon the rubber connections.

The two funnels upon either side are fixed at an equal height, of about 20 centimetres in each case, above the instrument, so as to ensure initial equality of pressure on the two sides of the membrane.

The osmometer is then suspended in a large vessel of water for the purpose of maintaining a constant temperature, which can be arranged at different levels by a thermo-regulator.

When the desired temperature has been attained, the osmometer is clipped off from the funnel connection on the solution side and left in communication with

[1] In earlier experiments the platinum lining was dispensed with and the silver-plated brass case only used. This makes the instrument much less expensive, and is effectual unless when the action of reagents, such as alkalies and acids, upon the colloid is to be tested.

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the monometer only. Thus the initial reading of the mercurial monometer gives the zero pressure, and subsequent readings at different time intervals after the commencement of the experimnet give the osmotic pressure.

The instrument has been used, up to the present date, with solutions of gelatine, starch, and gum acacia.

The experiments with gelatine show that the colloid can be used for experimentation in this osmometer without undergoing change for prolonged periods. Thus in one experiment which was carried on for eighty-six days the gelatine was recovered at the end as a clear jelly, setting at 21°–22° C., which showed no signs of alteration from that which was originally placed in the osmometer. Even after such a prolonged dialysis the pressure obtained at the end was, at the same temperature, the same as that at the beginning of the experiment. This proves that the pressure is not due to any diffusible crystalloid, which would have been equated by dialysis, but is produced by the dissolved colloid.

The figures for the osmotic pressure at a temperature of 40° C. give for the molecular weight in solution, or solution aggregate, of gelatine 18,600, which is of the same order of magnitude as the solution aggregates of various forms of proteid.

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3. *Experiments on the Permeability of Lipoïd Membranes.* *By* Professor Benjamin Moore, *M.A.*, *D.Sc.*

The theory has been enunciated by Overton that the osmotic properties of the cell are due to substances termed lipoïds, such as cholesterin and lecithin in the cell membrane, which are supposed to be impermeable to certain crystalloids such as sodium chloride, but freely permeable to water. So that these bodies act as semi-permeable membranes, and hence give rise to the osmotic phenomena shown by cells.

The theory has been extended by Overton and by Friedenthal to explain other important phenomena such as anæsthesia and fat-absorption by assuming that the lipoïds act as solvents, and take up into the cell the anæsthetics and fatty bodies.

Admitting that fats and anæsthetic substances are readily soluble in lecithin and allied bodies, it is difficult to see why these substances should be given up again from these lipoïds to the active protoplasmic constituents of the cell; and, further, there is no experimental proof that every cell is surrounded by such a lipoïd membrane.

But such an extensive use has been made of the theory which has received considerable credence that it appeared desirable to test whether membranes composed of such substances possess the properties which have been assigned theoretically to them.

Accordingly the osmometer described in the previous paper has been used for this purpose.

Membranes saturated with lecithin and lanoline have been employed, using sodium chloride solutions of different strengths on the two sides of the membrane, and also sodium chloride solution against distilled water. It has been found that such membranes are distinctly permeable to sodium chloride, as well as distilled water, and that no appreciable osmotic pressure is developed, showing that the osmotic phenomena of the cell are not due to such membranes, and that such membranes, if they did exist, furnish no explanation of the absorptive properties of the cell or of the phenomena of anæsthesia.

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4. *The Cerebrum of Apes.*[1] *By* Professor Sherrington, *F.R.S.*, *and* A. S. Grünbaum, *M.D.*

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5. *The Origin of Water in Saliva.* *By* Joseph Barcroft, *M.A.*, *B.Sc.*

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[1] To be published in the *Journal of Physiology*.

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SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION—Captain ETTRICK CREAK, C.B., R.N., F.R.S.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

OF the six distinguished naval officers who have previously presided over this Section, four were Arctic explorers; and therefore, possessing personal experience in Arctic regions, they naturally gave prominence to the deeply interesting subject of the past and future of Arctic discovery in their addresses, whilst not forgetting other matters relating to the geography of the sea. The remaining officers, from their immediate connection with all that relates to the physical condition of the ocean, in its widest sense, coupled with the great importance of giving the fruits of their knowledge to the world, took that subject as their principal theme.

Valuable as are contributions to our knowledge of the physics of the ocean to the world in general, and especially to the mariner and water-borne landsman, I propose to take a different course, and bring to your notice the subject of Terrestrial Magnetism in its relation to Geography. In doing so, I shall endeavour to show that much may be done by the traveller on land and the seaman at sea in helping to fathom the mysteries connected with the behaviour of the freely suspended magnetic needle, as it is carried about over that great magnet, the Earth, by observations in different regions, and even in limited areas.

I would, however, pause a moment to call attention to the presence of several distinguished meteorologists at this meeting, who will surely attract many to the consideration of matters connected with the important science of meteorology, which already occupies considerable attention from travellers. I feel sure, therefore, that geographers will be glad to accord a hearty welcome to the members of the International Meteorological Congress now assembled in this town, and especially to the foreign visitors who honour us by their presence.

Some one may ask, What has Terrestrial Magnetism to do with Geography? I reply, excellent lectures on that subject of growing importance have been given under the direct auspices of the Royal Geographical Society; one in 1878 by the late Captain Sir Frederick Evans, and another in 1897 by Sir Arthur Rücker. And I would here quote the opinion of Dr. Mill when defining geography, in my support: 'Geography is the science which deals with the forms of the Earth's crust, and with the influence which these forms exercise on the distribution of other phenomena.'

We know now that the normal distribution of the Earth's magnetism for any epoch is in many localities seriously affected accordingly as the nature of the country surveyed be mountainous, or generally a plain, in the form of islands (or mountains standing out of the sea), and from land under the sea. There is also reason to suspect that the magnetism of that portion of the earth covered by the

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oceans differs in intensity from that of the dry land we inhabit. A connection between the disturbances of the earth's crust in earthquakes and disturbances of the magnetic needle also seems to exist, although the evidence on this point is not conclusive.

Magnetic Surveys.

Previously to the year 1880 there were two periods of exceptional activity on the part of contributors to our knowledge of the earth's magnetism, during which the scientific sailor in his ship on the trackless ocean combined with his brethren on land in making a magnetic survey of the globe.

The first period was that of 1843–49, during which not only were fixed observatories established at Toronto, St. Helena, Capetown, and Hobart for hourly observations of the movements of the magnetic needle, but, to use Sabine's words, 'that great national undertaking, the Magnetic Survey of the South Polar Regions of the Globe,' the forerunner of our present Antarctic Expedition, was accomplished by Ross and his companions almost entirely at sea.

This Antarctic survey was carried out during the years 1840–45, and the results given to the world as soon as possible by Sabine. The results afterwards formed a valuable contribution when constructing his maps of equal lines of Magnetic Declination, Inclination, and Intensity for the whole world, a great work for the completion of which Sabine employed every available observation made up to the year 1870, whether on land or at sea.

Readers of these contributions cannot fail to be struck with the great number of observations made by such travellers as Hansteen and Due, Erman and Wrangel, extending from Western Europe to far into Siberia.

The second period was that of 1870–80, during which not only was there much activity amongst observers on land, but that expedition so fruitful to science, the voyage of H.M.S. 'Challenger,' took place. During the years 1872–76 we find the sailor in the 'Challenger' doing most valuable work in carrying out a magnetic survey of certain portions of the great oceans, valuable not only for needful uses in making charts for the seaman, but also as a contribution to magnetic science.

Prior to this expedition very little was known from observation of the distribution of Terrestrial Magnetism in the central regions of the North and South Pacific Oceans, and Sabine's charts are consequently defective there.

Combining the 'Challenger' magnetical results with those of all available observations made by others of H.M. ships, and by colonial and foreign governments, I was enabled to compile the charts of the magnetic elements for the epoch 1880, which were published in the report of the scientific results of H.M.S. 'Challenger.' I will venture to say that these charts give a fairly accurate representation of the normal distribution of the earth's magnetism between parallels of 70° N. and 40° S. Beyond these limits, either northward or southward, there is a degree of uncertainty about the value of the lines of equal value, especially in the Southern regions, an uncertainty which we have reason to hope will be dissipated when we know the full results obtained by Captain Scott and the gallant band he commands, for as yet we have to be content with some eddies of the full tide of his success.

Until the 'Discovery' was built, the 'Challenger' was the last vessel specially selected with a view to obtaining magnetic observations at sea, so that for several years past results obtained on land have been our mainstay. Thus, elaborate magnetic surveys with fruitful results have been carried out in recent years in the British Isles by Rücker and Thorpe. France, Germany, Holland, and some smaller districts in Europe have also been carefully surveyed, and British India partially so, by Messrs. Schlagintweit in 1857–58. The latter country is being again magnetically surveyed under the auspices of the Indian Government.

On the American continent the Coast and Geodetic survey of the vast territories comprised in the United States, which has been so many years in progress, has been accompanied by an extended magnetic survey during the last fifty-two years, which is now under the able direction of Dr. L. A. Bauer. Resulting from this some excellent charts of the magnetic declination in the United States

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have been published from time to time; and the last, for the epoch 1902, is based upon 8,000 observations.

There are other contributions to terrestrial magnetism for positions on various coasts from the surveying service of the Royal Navy, and our ships of war are constantly assisting with their quota to the magnetic declination, or variation, as sailors prefer to call it; and wisely so, I trow, for have they not the declination of the sun and other heavenly bodies constantly in use in the computation of their ship's position?

This work of the Royal Navy and the Indian Marine is one of great importance, both in the interests of practical navigation and of science; for besides the equipment of instruments for absolute determinations of the declination, dip, and horizontal force supplied to certain of our surveying-ships, every seagoing vessel in the service carries a landing compass, specially tested, by means of which the declination can be observed with considerable accuracy on land.

Although observers of many other objects may still speak of their 'heritage the sea' as a mine of wealth waiting for them to explore, unfortunately for magnetic observations we can no longer say 'the hollow oak our palace is,' for wood has been everywhere replaced by iron or steel in our ships, to the destruction of accurate observations of dip and force on board of them. Experience, however, has shown that very useful results, as regards the declination, can be obtained every time a ship is 'swung,' either for that purpose alone, or in the ordinary course of ascertaining the errors of the compass due to the iron or steel of the ship.

As an example of this method, the cruise of the training squadron to Spitzbergen and Norway in 1895 may be cited, when several most useful observations were made at sea in regions but seldom visited. Again, only this year a squadron of our ships, cruising together near Madagascar, separated to a distance of a mile apart and 'swung' to ascertain the declination.

I would here note that all the magnetic observations made by the officers of H.M. ships during the years 1890–1900 have been published in a convenient form by the Hydrographic Department of the Admiralty.

The fact remains, however, that a great portion of the world, other than the coasts, continues unknown to the searching action of the magnetic needle, whilst the two-thirds of the globe covered by water is still worse off. Amongst other regions I would specify Africa, which, apart from the coasts, Cape Colony, and the Nile valley to lat. 5½ N., is absolutely a new field for the observer.

Moreover, the elaborate surveys I have mentioned show how much the results depend upon the nature of the locality. I am therefore convinced that travellers on land, provided with a proper equipment of instruments for conducting a land survey of the strange countries which they may visit, and mapping the same correctly, can, with a small addition to the weight they have to carry, make a valuable contribution to our knowledge of terrestrial magnetism, commencing with observations at their principal stations and filling in the intermediate space with as many others as circumstances will permit.

The Antarctic Expedition.

Of the magnetic work of our Antarctic expedition we know that since the 'Discovery' entered the pack—and, as far as terrestrial magnetism is concerned, upon the most important part of that work—every opportunity has been seized for making observations.

Lyttelton, New Zealand (where there is now a regular fixed magnetic observatory), was made the primary southern base-station of the expedition; the winter quarters of the 'Discovery,' the secondary southern base-station. Before settling down in winter quarters, magnetic observations were made on board the ship during the cruise to and from the most easterly position attained off King Edward VII. Land in lat. 76° S., long. 152½° W., and she was successfully swung off Cape Crozier to ascertain the disturbing effects of the iron upon the compasses and dip and force instruments mounted in the ship's observatory.

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As a ship fitted to meet the most stormy seas and to buffet with the ice, the 'Discovery' has been a great success. Let me add another tribute to her value. From Spithead until she reached New Zealand but small corrections were required for reducing the observations made on board. The experience of Ross's Antarctic expedition had, however, taught the lesson that two wood-built ships, the 'Erebus' and 'Terror,' with but some 3° to 4° of deviation of the compass at Simon's Bay, South Africa, found as much as 56° of deviation at their position farthest south, an amount almost prohibitory of good results being obtained on board.

How fared the 'Discovery'? I have been told by Lieutenant Shackleton—for the cause of whose return to England we must all feel great sympathy—that a maximum of only 11° of deviation was observed at her most southerly position. From this we may look forward hopefully to magnetic results of a value hitherto unattained in those regions.

At winter quarters, besides the monthly absolute observations of the magnetic elements, the Eschenhagen variometers or self-registering instruments for continuously recording the changes in the declination, horizontal force, and vertical force were established, and in good working order at the time appointed for commencing the year's observations.

I may here remind you that some time previously to the departure of the British and German Antarctic expeditions, a scheme of co-operation had been established between them, according to which observations of exactly the same nature, with the same form of variometers, were to be carried out at their respective winter quarters during a whole year, commencing March 1, 1902. Besides the continuous observations with the variometers, regular term-days and term-hours were agreed upon for obtaining special observations with them at the same moment of Greenwich mean time. Both expeditions have successfully completed this part of their intended work.

To co-operate in like manner with these far southern stations, the Argentine Government sent a special party of observers to Staten Island, near Cape Horn, and the Germans another to Kerguelen Land, whilst New Zealand entered heartily into the work. In addition, similar observations were arranged to be made in certain British and colonial observatories, which include Kew, Falmouth, Bombay, Mauritius, and Melbourne; also in German and other foreign observatories.

We have all read thrilling accounts of the journeys of the several travelling parties which set out from the 'Discovery,' and of the imminent dangers to life they encountered and how they happily escaped them except one brave fellow named Vince, who disappeared over one of those mighty ice-cliffs, upon which all Antarctic voyagers descant, into the sea. In spite of all this there is a record of magnetic observations taken on these journeys of which only an outline has yet been given. Anticipations of the value of these observations are somewhat clouded when we read in one report that hills 'more inland were composed of granite rock, split and broken, as well as weatherworn, into extraordinary shapes. The lower or more outer hills consisted of quartz, &c., with basaltic dykes cutting through them.' Consequently, we have to fear the effects of local magnetic disturbances of the needle in the land observations, whilst buoyed up with the hope of obtaining normal results on board the ship.

Judging from some land observations which have been received, it appears that considerable changes have taken place in the values of the magnetic elements in the regions we are considering, but when making comparisons we have to remember the sixty years which have elapsed since Ross's time, and that he had nothing like the advantage of steam for his ships, or of instruments of precision like our present ship 'Discovery.' His ships also were, as we have already remarked, much worse magnetically, causing far more serious disturbance of the instruments. Hence the changes we note may not be entirely due to changes in the earth's magnetism.

The observations made by the officers of the 'Southern Cross' at Cape Adare in 1899–1900 also contribute to this question of magnetic change.

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The Magnetic Poles of the Earth.

I will now refer to those two areas on the globe where the dipping needle stands vertically, known as the magnetic poles. The determination of the exact position of these areas is of great importance to magnetic science, and I will just glance at what is being done to solve the problem.

Let us consider the North Pole first, the approximate position of which we know best from observation. If one were asked to say *exactly* where that pole has been in observation times, whether it has moved, or where it now is, the answer must be 'I do not know.' It is true that Ross in 1831, by a single observation, considered he had fixed its position, and I believe hoisted the British flag over the spot, taking possession thereof; but he may or may not have set up his dip circle over a position affected by serious magnetic disturbance, and therefore we must still be doubtful of his complete success from a magnetic point of view. Although eminent mathematicians have calculated its position, and Neumayer in 1885 gave a place to it on his charts of that year, we have still to wait for observation to settle the question, for one epoch at least.

Happily, I am able to repeat the good news that the Norwegian, Captain Roald Amundsen, sailed in June last with the express object of making a magnetic survey of Ross's position and of the surrounding regions, in order to fix the position of the north magnetic pole. Furnished with suitable instruments of the latest pattern, he proposes to continue his investigations until 1905, when we may look for his return and the fulfilment of our hopes.

As far as we can now see, the south magnetic pole cannot be approached very nearly by the traveller, and we can only lay siege to it by observing at stations some distance off but encircling it. We have our own expedition on one side of it, and now with the return of the 'Gauss' to South Africa in June last, we have learnt that that vessel wintered in lat. 66° 2′ S., long. 89° 48′ E., a position on the opposite side of the supposed site of the magnetic pole to that of the 'Discovery.' We may now pause to record our warm congratulations to Dr. von Drygalski and his companions on their safe return, accompanied by the welcome report that their expedition has proved successful.

In addition to the British and German expeditions, there are the Swedish expedition and the Scottish expedition. Therefore, with so many nationalities working in widely different localities surrounding it, we have every reason to expect that the position of the south magnetic pole will be determined.

The Secular Change.

When in the year 1600 Gilbert announced to the world that the earth is a great magnet, he believed it to be a stable magnet; and it was left to Gellibrand, some thirty-four years later, by his discovery of the annual change of the magnetic declination near London, to show that this could hardly be the case. Ever since then the remarkable and unceasing changes in the magnetism of the earth have been the subject of constant observation by magneticians and of investigation by some of the ablest philosophers in Europe and America. Year after year new data are amassed as to the changes going on in the distribution of the magnetism of the earth, but as yet we have been favoured by hypotheses only as to the causes of the wondrous changes which the magnetic needle records.

These hypotheses were at one time chiefly based upon a consideration of the secular change in the declination, but it is now certain that we must take into account the whole of the phenomena connected with the movements of the needle, if we are to arrive at any satisfactory result. Besides, it will not suffice to take our data solely from existing fixed observatories, however relatively well placed and equipped, and valuable as they certainly are, for it now appears that the secular change is partly dependent upon locality, and that even at places not many miles apart differences in results unaccounted for by distance have been obtained.

The tendency of observation is increasingly to show that the secular change of the magnetic elements is not a world-wide progress of the magnetic needle moving

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regularly in certain directions, as if solely caused by the regular rotation during a long series of years of the magnetic poles round the geographical poles, for if you examine Map No. 1, showing the results of observations during the years 1840–80 as regards secular change, you will observe that there are local causes at work in certain regions, whilst in others there is rest, which must largely modify the effect of any polar rotation.

Allow me to explain further. The plain lines on Map No. 1 indicate approximate regions of no secular change in the declination, and the small arrows the general direction (not the amount) in which the north-seeking end of the horizontal needle was moving during those forty years. The foci of greatest change in the declination, with the approximate amount of annual change in the northern hemisphere, are shown in the German Ocean and N.W. Alaska, in the southern hemisphere off the coast of Brazil, and in the South Pacific between New Zealand and Cape Horn. The two foci of greatest annual change in the dip are shown, one in the Gulf of Guinea where the north-seeking end of the needle was being repelled strongly upwards, the other on the west side of Tierra del Fuego, where the north-seeking end of the needle was being attracted strongly downwards.

It is remarkable that the lines of no change in the declination pass through the foci of greatest change in the dip. If the needle be repelled upwards, as at the Gulf of Guinea focus, it will be found to be moving to the eastward on the east side of the whole line of no change in the declination from the Cape of Good Hope to Labrador; to the westward on the west side. If the needle be attracted downwards, as at the Tierra del Fuego focus, it will be found moving to the westward on the east side of the whole line of no declination from that focus to near Vancouver Island; to the eastward on the west side.

A similar result may be seen in the line passing through a minor focus of the dip near Hong Kong.

Judging from analogy there should be another focus of change in the dip in lat. 70° N., long. 115° E., or about the position assigned to the Siberian focus of greatest force.

On Map No. 2 are shown lines of equal value of the declination—the red lines for the year 1880, the black lines for the year 1895. From these, when shown on a large scale, we may deduce the mean annual change which has taken place in the declination during the fifteen years elapsed.

In this map we are reminded of the different results we obtain in different localities, for if a line be drawn from Wellington in New Zealand past Cape York in Australia to Hong Kong, little or no change will be found in the neighbouring region since 1840. Again, the line of no change in the declination shown on Map No. 1 to be following much the same direction as the great mountain ranges on the west side of the American continent, has hardly moved for many years according to the observations available.

On the other hand, let us now turn to an example of the remarkable changes which may take place in the declination unexpectedly and locally. The island of Zanzibar and the east coast of Africa were constantly being visited by our surveying-ships and ships of war up to the year 1880, observations of the declination being made every year at Zanzibar during the epoch 1870–80. The results showed that from Capetown nearly to Cape Guardafui the annual change of that element hardly exceeded 1.

During the succeeding years of 1890–91 observations were made by the Germans at Dar-es-Salaam and some other places on the neighbouring coasts, with the result that the declination was found to be changing at first 3′ annually, and since that period it had reached 10′ to 12′ at Dar-es-Salaam. Subsequent observations at the latter place in 1896–98 confirmed the fact of the great change, and in addition our surveying-ship on the station, specially ordered to 'swing' at different places in deep water off the coast, generally confirmed the results. It is remarkable that whilst such great changes should have taken place between Capetown and Cape Guardafui, Aden and the region about the straits of Bab-el-Mandeb seem to be comparatively unaffected

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Local Magnetic Disturbance.

In Map No. 2 normal lines of equal value of the declination are recorded, and as far as the greater part of the globe covered by water is concerned, we may accept them as undisturbed values, for we have yet to learn that there are any local magnetic disturbances of the needle in depths beyond 100 fathoms.

When, however, we come to the land, there is an increasing difficulty in finding districts of only a few miles in extent where the observed values of the magnetic elements at different stations therein do not differ more widely than they should if we considered only their relative position on the earth as a magnet. Take Rücker and Thorpe's maps of the British Isles and those of the United States, for example, where the lines of equal value are drawn in accordance with the observations, with the result that they form extraordinary loops and curves differing largely from the normal curves of calculation.

From among numerous examples of disturbance of the declination on land, two may be quoted. In the Rapakivi district, near Wiborg, a Russian surveying officer in the year 1890 observed a disturbance of 180°, or, in other words, the north point of his compass pointed due south. At Invercargill, in New Zealand, within a circle of 30 feet radius, a difference of 56° was found. Even on board ships in the same harbour different results are sometimes observed, as our training squadron found at Reikiavik in Iceland, and notably in our ships at Bermuda.

It is hardly necessary to add that the dip and force are often largely subject to like disturbance, but I do so in order to warn travellers and surveyors that observations in one position often convey but a partial truth; they should be supplemented by as many more as possible in the neighbourhood or district. Erroneous values of the secular change have also been published from the various observers not having occupied exactly the same spot, and even varied heights of the instrument from the ground may make a serious difference, as at Rapakivi before mentioned, and at Madeira, where the officers of the 'Challenger' expedition found the dip at a foot above the ground to be 48° 46′ N.; at 3¼ feet above the ground 56° 18′ N. at the same spot.

All mountainous districts are specially open to suspicion of magnetic disturbance, and we know from comparison with normal observations at sea that those mountains standing out of the deep sea, which we call islands, are considerably so affected.

Magnetic Shoals.

The idea that the compasses of ships could be affected by the attraction of the neighbouring dry land, causing those ships to be unsuspectingly diverted from their correct course, was long a favourite theory of those who discussed the causes of shipwreck, but it was 'a fond thing vainly invented.' I can hardly say this idea is yet exploded, but from what has already been said about local magnetic disturbance on land, it is not a matter of surprise that similar sources of disturbance should exist in the land *under* the sea, for it has been found that in certain localities, in depths of water sufficient to float the largest ironclad, considerable disturbances are caused in the compasses of ships.

An area of remarkable disturbance having been reported as existing off Cossack, N.W. Australia, H.M.S. 'Penguin,' a surveying-ship provided with the necessary magnetic instruments, was sent by the Admiralty in 1891 to make a complete magnetic survey of the locality, with a view to ascertaining the facts and placing them on a scientific basis. An area of disturbance 3·5 miles long by 2 miles broad, with not less than 8 fathoms of water over it, was found lying in a N.E. by E. and S.W. by W. direction. At one position the disturbing force was sufficient to deflect the 'Penguin's' compass 56°; in another—the focus of principal disturbance—the dip on board was increased by 29°, and this at a distance of over 2 miles from the nearest visible land, upon which only a small disturbance of the dip was found.

This remarkable area of disturbance was then called a 'Magnetic Shoal,' a term

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which at first sight hardly appears to be applicable. We have, however, become familiar with the terms 'ridge line, valley line, peak, and col,' as applied to areas of magnetic disturbance on land; therefore I think we may conveniently designate areas of magnetic disturbance in land under the sea 'Magnetic Shoals.'

This year H.M. surveying-ship 'Research' has examined and placed a magnetic shoal in East Loch Roag (Island of Lewis), but as all our surveying-ships are practically iron ships, it was impossible from observations on board to obtain the exact values of the disturbing forces prevailing in this shoal. The reason for this is that, although we may accurately measure the disturbing forces of the iron of the ship in deep water, directly she is placed over the shoal induction takes place, and we can no longer determine to what extent the observed disturbances are due to the ship's newly developed magnetism, or to what extent the shoal alone produces them.

We can, nevertheless, even in an iron ship, accurately *place* and show the dimensions of a magnetic shoal and the *direction* in which a ship's compass will be deflected in any part of it by compass observations only. Is it not, therefore, the duty of any ship meeting with such shoals to stop and fix their position?

The general law governing the distribution of magnetism on these magnetic shoals is that in the northern hemisphere the north point of the compass is drawn *towards* the focus of greatest dip; in the southern hemisphere it is *repelled*. The results at East Loch Roag proved an exception, the north point of the compass being *repelled*.

Terrestrial Magnetism and Geology.

I have already referred to the question of local magnetic disturbance as one of great importance in magnetic surveys. The causes of these disturbances were at one time a matter of opinion, but the evidence of the elaborate magnetic surveys I have alluded to, when compared with the geological maps of the same countries, points clearly to magnetic rocks as their chief origin.

Magnetic rocks may be present, but from their peculiar position fail to disturb the needle; but, on the other hand, as Rücker writes in his summary of the results of the great magnetic survey of the British Isles conducted by Thorpe and himself, 'the magnet would be capable of detecting large masses of magnetic rock at a depth of several miles,' a distance not yet attained by the science of the geologist.

Again, Dr. Rijckevorsel, in his survey of Holland for the epoch 1891, was convinced that 'in some cases, in many perhaps, there must be a direct relation between geology and terrestrial magnetism, and that many of the magnetic features must be in some way determined by the geological structure of the underground.'

During the years 1897–99 a magnetic survey was made of the Kaiser-stuhl, a mountainous district in the neighbourhood of Freiburg in Baden, by Dr. G. Meyer. Exact topographical and geological surveys had been previously made, and the object of the magnetic survey was to show how far the magnetic disturbances of the needle were connected with geological conformations. Here, again, it was found that the magnetic and geological features of the district showed considerable agreement, basaltic rocks being the origin of the disturbance. This was not all, for in the level country adjacent to the Rhine and near Breisach unsuspected masses of basalt were found by the agency of the magnetic needle.

More recently we find our naval officers in H.M.S. 'Penguin,' with a complete outfit of magnetic instruments, making a magnetic survey of Funafuti atoll and assisting the geologist by pointing out, by means of the observed disturbance of the needle, the probable positions in the lagoon in which rock would be most accessible to their boring apparatus.

Leaving the geologist and the magnetician to work in harmony for their common weal, let us turn to some other aspects of the good work already accomplished and to be accomplished by magnetic observers.

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Magnetic Charts.

Of the valuable work of the several fixed magnetic observatories of the world, I may remark that they are constantly recording the never-ceasing movements of the needle, the key to many mysteries to science existing in the world and external to it, but of which we have not yet learnt the use. Unfortunately many of these once fixed observatories have become travellers to positions where the earth can carry on its work on the needle undisturbed by electric trams and railways which have sprung up near them, and it is to be hoped they will find rest there for many years to come.

Of the forty-two observatories which publish the values of the magnetic elements obtained there, thirty-two are situated northward of the parallel of 30° N., and only four in south latitude; and it is a grief to magneticians that so important a position as Capetown or its neighbourhood does not make an additional fixed magnetic observatory of the first order.

Thus, as far as our present question of magnetic charts and their compilation is concerned, the observatories do not contribute largely, but we should be very grateful to them for the accurate observations of the secular change they provide which are so difficult to obtain elsewhere.

Of the value of magnetic charts for different epochs I have much to say, as they are required for purely scientific inquiry as well as for practical uses. It is only by their means that we can really compare the enormous changes which take place in the magnetism of the globe as a whole; they are useful to the miner, but considerably more so to the seaman. Had it not been for the charts compiled from the results of the untiring labours of travellers by land and observers at sea in the field of terrestrial magnetism during the last century, not only would science have been miserably poorer, but it is not too much to say that the modern iron or steel steamship traversing the ocean on the darkest night at great speed would have been almost an impossibility, whereas with their aid the modern navigators can drive their ships at a speed of 26·5 statute miles an hour with comparative confidence, even when neither sun, moon, nor stars are appearing.

Of the large number of travellers by sea, including those who embark with the purpose of increasing our geographical knowledge of distant lands and busying themselves with most useful inquiries into the geology, botany, zoology, and meteorology of the regions they visit, few realise that when they set foot on board ship (for all ships are now constructed of iron or steel) they are living inside a magnet. Truly a magnet, having become one by the inductive action of that great parent magnet—the Earth.

How fares the compass on board those magnets, the ships, that instrument so indispensable to navigation, which Victor Hugo has forcibly called 'the soul of the ship,' and of which it has been written,

> 'A rusted nail, placed near the faithful compass,
> Will sway it from the truth, and wreck an argosy'?

And if so small a thing as an iron nail be a danger, what are we to say to the iron ship? Let us for a moment consider this important matter.

If the nature of the whole of the iron or steel used in construction of ships were such as to become permanently magnetic, their navigation would be much simplified, as our knowledge of terrestrial magnetism would enable us to provide correctors for any disturbing effects of such iron on the compass, which would then point correctly. But ships, taken as a whole, are generally more or less unstable magnets, and constantly subject to change, not only on change of geographical position, but also of direction of the ship's head with regard to the magnetic meridian. Thus a ship steering on an easterly course may be temporarily magnetised to a certain extent, but on reversing the ship's course to west she would after a time become temporarily magnetised to the same amount, but in the opposite direction, the north point of the compass being attracted in each case to that side of the ship which is southernmost.

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Shortly, we may define the action of the earth's magnetism on the iron of a ship as follows: The earth being surrounded by a magnetic field of force differing greatly in intensity and direction in the regions from the North Pole to the Equator and the Equator to the South Pole, the ship's magnetic condition is largely dependent upon the direction of her head whilst building and the part of that field she occupied at the time; partly upon her position in the magnetic field she traverses at any given time during a voyage.

For the reasons I have given, magnetic charts are a necessity for practical purposes and in the following order of value. That of the magnetic declination or variation which is constantly in use, especially in such parts of the world as the St. Lawrence and the approaches to the English Channel, where the declination changes very rapidly as the ship proceeds on her course. Next, that of the dip and force, which are not only immediately useful when correcting the ship's compass, but are required in the analysis of a ship's magnetism both as regards present knowledge and future improvements in placing compasses on board.

If astronomers have for a very long time been able to publish for several years in advance exact data concerning the heavenly bodies, is it too much to hope that magneticians will before long also be able to publish correct magnetic charts to cover several years in advance of any present epoch? If this is to be done within reasonable time there must be a long pull, a strong pull, and a pull all together of magnetic observers in all lands, and accumulated data must also be discussed.

On Magnetic Instruments for Travellers.

Travellers in unsurveyed countries, if properly instructed and equipped, can do good service to science by observing the three magnetic elements of declination, inclination or dip, and force at as many stations as circumstances will permit; hence the following remarks.

For the purpose of making the most exact magnetic survey the best equipment of instruments consists of the well-known unifilar magnetometer, with fittings for observing the declination, and a Barrow's dip circle. To some travellers these instruments might be found too bulky, and in some regions too delicate as well as heavy to carry.

Of suitable instruments made abroad, those used by M. Moureaux in his survey of France may be mentioned, as they are of similar type, but much smaller and lighter than the instruments above mentioned.

Another form of instrument, called an L.C. instrument, for observing both the inclination and total force, is shown in the instrument before you. Originally designed for observations on board ships at sea where the ordinary magnetic instruments are unmanageable, it has also been found to give satisfactory results in a land survey, where greater accuracy is expected than at sea. Thus, during a series of observations extending from the north side of Lake Superior to the southern part of Texas last year, comparisons were made between the results obtained with an L.C. instrument and those of the regular unifilar magnetometer and dip circle, when the agreement was found satisfactory.

I am therefore of the opinion that a traveller furnished with a theodolite for land-surveying purposes, but fitted with a reversible magnetic needle, can at any time he observes a true bearing obtain a trustworthy value of the declination. Dismounting the theodolite from his tripod, the latter will serve for mounting an L.C. instrument with which to observe the inclination and force. Thus, by adding to his ordinary equipment an instrument weighing in its box about 21 lb., he can obtain valuable contributions to terrestrial magnetism, and at the same time give useful assistance to geological investigations.

Concluding Remarks.

Although a great subject like terrestrial magnetism, even to exhibit our present knowledge of the science, cannot be brought within the compass of an address—for it requires a treatise of many pages—I have brought some of the

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broad features of it before the Section in order to show its connection with Geography.

I also entertain the hope that geographers will become more interested in a subject so important to pure science and in its practical applications, and that it will become an additional subject to the instruction which travellers can now obtain under the auspices of the Royal Geographical Society in geology, botany, zoology, meteorology, and surveying.

There is a wide field open to observers, and where results often depend so much upon locality we require to explore more and more with the magnetic needle. To look over the great oceans and think how little is being done for terrestrial magnetism is a great matter for regret. Yet even there we may begin to be hopeful, for the United States Coast and Geodetic Survey authorities are making arrangements to fit out its vessel with the necessary instruments for determining the magnetic elements at sea.

We wish them all success; but I must again remind you that although we cannot compel observers to start, there is room for them and to spare.

I would fain make some remarks on the prevailing ignorance of sound geography in many quarters, and on the defective methods of teaching the science; but I feel that the subject is placed in very able hands, and will be fully discussed elsewhere during the present meeting.

The following Papers were read:—

1. *The recent West Indian Eruptions.*[1]
By TEMPEST ANDERSON, *M.D.*, *B.Sc.*

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2. *The Economic Development of West Africa.*[2] *By* E. D. MOREL.

Although West African affairs are engaging more and more attention, the public as a whole continues to display a curious indifference to that part of the world. Yet there are urgent reasons why a manufacturing nation like ours should show keener interest in one of the greatest raw material-producing countries in the world, of which we possess some 700,000 square miles, inhabited by 30,000,000 people. The author of the paper protests against the indifference of the public: the extent of British commercial interests in West Africa is ignored by most, and the future potentialities of the country are insufficiently appreciated. The chief factor which determined the Powers to assume the liabilities they have in tropical Africa was due to the belief that raw material is necessary to an industrial and manufacturing nation, and that each nation must find new markets for the consumption of home manufactures, markets which will pay for such manufactures in raw material. It follows, therefore, that the economic development of tropical Africa is the principal aim which each Power has in view. How can that economic development be best pursued in a manner profitable to the people of Europe and to the people of Africa? If it is to be permanently successful, it must be profitable to both.

The paper goes on to point out that two political conceptions—utterly divergent and antagonistic, yet both alike concerned with the economical development of tropical Africa, and therefore both alike arising from the cardinal factor which led to the partition of tropical Africa among the Powers—are before the world. The adoption of one or the other conception will decide the future of European effort in the black man's country. The two conceptions are defined as Coercion and Commerce: the former is characterised as a revival in aggravated form of the old culture system of the Dutch East Indies, which had to be abandoned

[1] The subject-matter of the lecture appeared in the *Geographical Journal* for March 1903.

[2] Printed in full in the *West African Mail*, September 18 and 25, 1903.

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owing to the ruin and exhaustion it brought with it. This system is at present in operation in a large portion of tropical Africa. It is based upon the repudiation, or rather the ignoring, of native rights of land tenure; upon the definition of all land not actually built over or cultivated for food-stuffs as 'vacant'; and upon the appropriation of all such land and the produce yielded by it. It tends towards the enslavement of whole peoples and brings inevitable ruin in its train. Arguments are adduced to show that, apart from its moral side, this conception is antagonistic to the development of all legitimate European aims in tropical Africa, and that if it is morally pernicious it is also practically short-sighted and injurious, and should be resisted to the uttermost.

The other conception has, the author contends, notwithstanding many material obstacles, produced results which are obvious and visible to all. It is based upon the recognition that the inherent rights of a native of tropical Africa to his land and the produce thereof are the necessary accompaniments of all successful and permanent development work in the interests both of the European and the negro. The commercial instincts of the negro are notorious, his adaptability remarkable; the theory that he will not work is untenable in face of the positive results of his labours in the millions of pounds' worth of produce shipped home annually to Europe from West Africa. He merely requires instruction and guidance to prevent wastage and destruction of economic products due to want of knowledge in the preparation and collection of the raw material. An urgent necessity is the careful study of native land tenure as an important factor in economic development, the theory of 'vacant' lands being often misleading and open to grave abuses.

The paper then discusses the best means of improving native industries and helping the native to construct new ones, laying particular stress upon the great importance of extending the growth of cotton in, and promoting its export from, the tropical African provinces of the Empire. Reference having been made to various measures which might with advantage be taken by Government to secure these ends, the opinion is expressed that the only right and practical ideal which should govern European action in tropical Africa (which is, and must always remain, a black man's country, where the European cannot colonise and can only supervise) is to teach the native to take pride in his property; to guarantee him from molestation in his ownership of his property; to assist him in developing the raw products his fertile soil yields for his own advantage and ours; to make it clear to him that we look upon him, not as a fool, still less as a brute, but as a partner in a great undertaking which, if properly conducted, will confer lasting benefit upon his race and the white over-lords who have established themselves in his midst.

FRIDAY, SEPTEMBER 11.

The following Papers and Report were read:—

1. *The Influence of Ice-melting upon Oceanic Circulation.*[1]

By Professor O. Pettersson.

The circulation of oceanic waters has been ascribed partly to physical causes, such as the heating of surface waters in tropical and the cooling in polar regions, partly to mechanical causes, such as the influence of the prevailing winds. The latter is at present regarded as the chief motive power of the currents of the sea. In either case the *vis movendi* must be the effect of a thermodynamic cycle of the free heat in the atmosphere or in the hydrosphere. On the mechanical hypothesis it is obvious that the primary effect is the generation of surface-currents (wind-currents) of great intensity, and that the intensity of motion must decrease with the depth. The general conviction at present is that the movement of the bottom

[1] The Paper will probably appear *in extenso* in the *Geographical Journal*.

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waters of the ocean is extremely slow (*vide* G. Schott's description of the results of the German Valdivia expedition).

In 1878 the author pointed out that a great—and probably the greatest—part of the oceanic current system must be due to another cause, viz., the thermodynamic cycle of latent heat, consisting in the formation of ice in polar regions and the melting of ice in sea-water at lower latitudes.[1] In 'Petermann's Mitteilungen,' 1900, Heft I. and II., he calculated the energy generated by the melting of ice in the sea between Iceland and Jan Mayen to be about 400,000 horse-power, which energy is employed in accelerating the movement of the waters of the East Iceland polar current, which makes its way from the sea between Iceland and Jan Mayen towards the Färoes, there to dip under the current of Atlantic water which sets in between the Shetlands and the Färoes, and ultimately vanishes into the Atlantic depths in the shape of a submarine waterfall over the Iceland-Färoe and W. Thomson bank. The energy set free on the melting of ice in sea-water is expended on raising the water from the submerged part of the ice to the surface, and may be likened to a waterfall where the water, instead of descending, arises from below to the surface. The heat necessary for this melting is supplied from undercurrents of warm Atlantic water, which exist wherever the melting of ice goes on in the ocean. One part (in the case referred to about $\frac{1}{13}$) of this warmer and salter water mixes with the ice-water and forms the polar surface-current, while the greater part (here about $\frac{12}{13}$) is cooled to a temperature approaching the temperature of equilibrium between ice and salt water, and sinks to the bottom, there to form the layer of cold water which is known to exist in all oceans. The temperature and the salinity of this bottom water depend upon the relation between the quantity of ice which is melted and the amount of warm water supplied by the undercurrent. In the Atlantic Ocean the temperature is a little below or above + 2°, which shows that the warm water here is in excess of the ice. In the Norwegian Sea the bottom temperature is about − 1·4° C., *which is the lowest existing on the globe.* This shows that the warm water supplied by the Atlantic current is just sufficient to melt the ice which is brought down along the coast of Greenland by the polar current. It is inferred from this that the state of this part of the sea is in a very unstable equilibrium, which may account for the instability of the climate of the northern countries of Europe and the great variations in the extension of the ice in this sea. In the Polar Sea we meet with the startling fact, discovered by Nansen, that the bottom temperature is *higher* than in the Norwegian Sea, or above − 0·9° C. This is explained by the fact that the ice in the polar sea floats in a layer of cold water diluted by the admixture of river-water from Siberia. Thereby the access to the ice of the warm and salt undercurrent, which Nansen discovered at about 200 m. depth, is more or less prevented. The ice-melting in the polar sea thereby becomes less intense, the surface of the sea is filled with ice-floes and pack-ice, which must be carried out into the Norwegian Sea or the Atlantic in order to melt. Therefore the cooled bottom layer has a higher salinity and temperature than in the adjacent Norwegian Sea.

The influence of the thermodynamic cycle of latent heat upon oceanic circulation is characterised by the following circumstances:—

1. The seat of the accelerating force is *localised* in the meeting places of the ice-currents of polar origin with warm currents. The most important of these places are the seas between Iceland and Jan Mayen, W. of Spitzbergen, S.E. of Newfoundland, and the ice girdle encircling the Antarctic Sea.

2. In all such places warm undercurrents are found to exist under the ice. The melting process is maintained chiefly at the cost of the heat stored up in the waters of the undercurrent. The system of currents and undercurrents of the Norwegian Sea is represented on a chart prepared by the author.

3. The warm water of the undercurrent, which in the northern hemisphere is denoted by the name of 'Atlantic' water (alias Gulf Stream water), is modified by

[1] *Öfvers. Kgl. Vetenskaps-Akademiens Forhandl.*, 1878, No. 2, p. 61, and *On the Properties of Water and Ice* (Vegaexpeditionens iakttagelser, Stockholm, 1883).

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its contact with the ice into 'Arctic' water.[1] One part of this Arctic water consists of Atlantic water diluted with ice-water. This kind of water rises to the surface and contributes to the maintenance of the polar currents. The other and greater part consists of Atlantic water, which has given up its surplus of heat and sunk to the bottom, there to form the great cold bottom layer of the oceans.

4. The warm undercurrents always follow the trend of the deepest isobathic lines, while the ice-currents only exist over shallow parts of the sea. As soon as an ice-current leaves the coast-bank and takes its way over a deep part of the ocean, its ice is exposed to melting by the warm undercurrent, which is attracted by the ice and maintained by the energy set free at the melting process.

5. The above-mentioned chart shows a remarkable example of how north-going warm currents and undercurrents are deviated to the west in the Norwegian Sea, in spite of the powerful influence of the earth's rotation.

6. The metamorphosis of Atlantic water into Arctic water involves also a biological change. The foraminifers, &c., of the Atlantic die out (as already shown by Sir J. Murray) in contact with the cold water and sink to the bottom, there to form calcareous deposits. Consequently the course of the warm undercurrents can be traced up to the highest latitudes by a surplus of CaO in the bottom sediments.

7. The author's experiments with exact measurements in the Skagerrack and the Baltic show that the motion of the deeper layers there is by no means insignificant or slow, as it is judged to be by the advocates of the 'wind-theory,' but is, as a rule, *stronger* than that of the surface water. How far this holds with regard to the deeper parts of the oceans remains to be investigated. Therefore current measurements in the Atlantic at depths of 800–4000 m. are a pressing desideratum in oceanography.

8. As the accumulation of polar ice varies with the season, and is influenced by terrestrial (meteorological) as well as cosmical phenomena (radiation, &c.), it is evident that the current system set in action by the cycle of latent heat must show periodical variations with the seasons and also periodical or non-periodical variations of longer duration. Are there any indications of such variations in the movement of the undermost layers of the sea? The author's experience is that there are such indications, and this discovery has led him to propound the present theory.

9. The Antarctic Ocean presents the grandest example of ice-melting and of variations in ice-melting. It must be borne in mind that the energy liberated by ice-melting in the ocean is proportional to the depth of the submerged part of the ice. From an iceberg 500 m. in depth the melting of one kilogram of ice will produce an amount of work equal to 7 kilogram-metres. Great 'outbursts' of icebergs from the Antarctic are known to happen from time to time (Russell). Such outbursts, which carry icebergs down to low latitudes in the Indian Ocean, may exercise influence upon the climate of India, Australia, &c., as thereby part of the warm area of the ocean from which the water evaporates, which ultimately falls as monsoon rain upon the coasts of these countries, may be encroached upon by cold polar water. It is a matter worth notice that the last great 'outburst' from the Antarctic and the last great droughts of India fall within the same period of years (1891–1898). By means of regular surface observations on board of liners crossing the Indian Ocean and a few series of deep soundings along the 60th and 100th meridians such yearly variations in the hydrographic state of the Indian Ocean as can be of meteorological interest might be ascertained.

In order to put the theory of the influence of ice-melting to a test the author has carried out a series of experiments so arranged as to correspond as nearly as possible to the natural conditions of the Norwegian Sea, and has compared the results with the actual results of the Norwegian and Swedish hydrographic research in this part of the ocean in 1900. A description of the last experiment of the series, carried out by Mr. J. W. Sandström, assisted by Miss A. Palmquist, is given in the next paper.

[1] It is evident that in the course of oceanic circulation there must be a transition of Atlantic water into Arctic water, and *vice versa*. The first-named metamorphosis is effected by the ice-melting process.

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2. *An Experiment on the Melting of Ice in Salt Water.*

By J. W. SANDSTRÖM.

At the request of Professor Pettersson the author repeated one of the ice-melting experiments mentioned in the preceding paper on a larger scale in the Central Laboratory for Oceanic Research at Christiania, Professor Nansen kindly placing at his disposal the large tank, 3·5 metres in length by 0·4 metre in height and 0·7 metre broad, which had served in his own investigations. This tank was filled to a depth of 35 cm. with salt water at 7° C. and 30 per cent. salinity. The tank was divided into two compartments by a partition 30 cm. high. Above this wall there was free communication between the water in the two compartments.

In the right compartment (which represents the Norwegian Sea) a rectangular ice block 50 kilogrammes in weight was introduced. While melting it assumed a very peculiar shape.

In the left compartment (Atlantic) an extra current was set going, carrying twelve litres per hour of water of the same salinity and temperature in and out of the vessel at a constant level. The movement of the water in the other compartment was studied by means of fine jets of $KaMnO_4$ solution which were made to ascend from capillary tubes at the bottom. The deflection from the vertical of these jets was measured every ten minutes. Thus a good estimate of the velocity at different levels was obtained.

Before the introduction of the ice block in the right compartment the jets indicated an almost entire absence of movement of the waters of this compartment, although the extra current was circulating constantly in the other (Atlantic). With the introduction of the ice the conditions changed. Three different currents could be discerned to the right of the partition wall, which represented the Färoe-Shetland or Färoe-Iceland ridge. From the left (Atlantic) an under-current was attracted towards the under-side of the ice, where it reached its maximum velocity of 0·23 cm. per second. From the farthermost side of the ice block, where the under-current impinged, cold diluted water arose to the surface and formed an outgoing 'polar' current the maximum velocity of which was found to be 0·03 cm. per sec. From the ice, cold and dense water descended to the bottom, where it formed a powerful outgoing current with a maximum velocity of 0·14 cm. per sec. The bottom current had an upward tendency near the partition wall, over which it flowed into the Atlantic compartment. All measurements were made after the conditions had become established, which was found to be the case after two hours. The volume of water carried by the under-current towards the ice was about twenty-seven times the volume carried by the returning bottom current, and about twelve times greater than that of the surface current.[1]

By observation of the motion of small particles of insoluble matter held in suspension by the water the current lines in the middle vertical section of the tank were constructed.

Accurate observations of salinity and temperature at all depths were made by the chemist of the Swedish Hydrographical-Biological Commission (Miss Palmquist) and the density *in situ* of the water computed from Knudsen's tables. From these data the accelerating forces of the circulation were calculated according to V. Bjerknes, 'Ueber einen hydrodynamischen Fundamentalsatz und seine Anwendung besonders auf die Mechanik der Atmosphäre und des Weltmeeres.'[2] The result was to show that the accelerating forces counteracted the circulation in the part of the right compartment most remote from the ice, while they aided the circulation in the neighbourhood of the ice. The aiding forces (= 0·57 c.g.s. solenoids), however, exceeded those counteracting (= 0·18 c.g.s. solenoids), the difference (= 0·39 c.g.s. solenoids) being the resultant of two acting forces.

[1] This is according to measurements taken in the central longitudinal section of the tank. At the sides the motion is more retarded by friction, which accounts for the fact that the volume of the ingoing and outflowing water was not found to be equal.

[2] *K. D. V. Aks. Handl.* Bd. 31, 1898.

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The same remarkable distribution of forces is found to exist in the sea. In the longitudinal section of the Norwegian Sea for July and August 1900, constructed by Professor Pettersson, there are 10,050 c.g.s. solenoids between lat. 77° and 70° in aid of the circulation and 3025 c.g.s. solenoids commencing this circulation between lat. 70° and 64°. The accelerating force which maintains the oceanic circulation in this section of the Norwegian Sea thus is equal to 7025 c.g.s. solenoids. The seat of these forces is the immediate neighbourhood of the ice.

Putting aside the influence of the earth's rotation and of friction, we find that this set of forces is sufficient to increase the velocity of the water by 14 cm. per sec. in one week.

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3. *Report of the Committee on Terrestrial Surface Waves.*
See Reports, p. 312.

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4. *The British Antarctic Expedition.* *By* Lieut. E. SHACKLETON.

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5. *Explorations and Economic Conditions in Western China.*
By Lieut.-Col. C. C. MANIFOLD.

The paper embraced an account of two journeys to the regions of the Upper Yang-tse immediately before and after the Boxer outbreak. The first journey, in 1900, lasted for seven months and ranged from Burma to Tibetan territory and across China to Shanghai; and the second, made in 1901–2, lasted for nine months and took the author from Peking almost back to the confines of Burma. The distance covered was nearly 6,000 miles of land travel on foot and 3,000 miles on inland waterways. The starting-point of the first journey was Bhamo, our frontier garrison town on the borders of Burma and China, likewise the starting-point of large trains of coolies and mules carrying Indian yarn into China. A start was made just at the time of the Chinese new year, and on the second day Chinese territory was entered. The road taken was a well-known trade route to Teng-yueh, the nearest large trading centre in Yun-nan, a town more commonly known by the name of Momein. It has been proposed to connect Bhamo and Teng-yueh by railway, and though it would not be feasible to carry the line any further, a distance of only 130 miles, even this sort of line would pay its way and increase our trade and influence in Yun-nan. After touching the Yang-tse above its great bend, the author went north-west to join Captains Davies and Ryder, who had started in December 1899, by routes which touched on the line the proposed railway from Burma to the Yang-tse Valley would have followed. The advantages which would accrue from such a railway, if it could be constructed at reasonable cost, are undoubted, but great natural difficulties exist from the formation of the country, and the cost would be enormous. The project, however, must not be subjected to sweeping condemnation. Yun-nan-Fu, the capital of the sparsely populated and at present poor province of Yun-nan, is the halfway house to the rich regions of the Upper Yang-tse. A French company has obtained a concession for a railway from the frontier in Tonking to Yun-nan-Fu, and they hope in time to carry it to the Upper Yang-tse and so divert the trade to their own port of Hanoi. The construction of the line has already been started under the guarantee of the French Government. The country of Yun-nan is mountainous and sparsely populated, but very rich in minerals. After meeting with great difficulties in crossing the higher passes, some of which reached an altitude of 13,000 feet or 14,000 feet, and were badly blocked with snow, the party reached the rendezvous on April 6, at a point where the western frontier of the province of Sechuan and British India at the eastern frontier of Assam are separated by a distance of little more than 260 miles. Reaching Ta-Chien-lu, the travellers found telegrams warning them of the disturbances

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They, however, determined to push on and try to effect an exit by the Yang-tse River. From Ta-Chien-lu, they followed the great tea road between Tibet and China, so called because of the great traffic in tea carried between Lhasa and Ya-chou. The lecturer pointed out that if free commercial relations could be established with Tibet there was no doubt that the better and cheaper Indian tea would capture this market. From Ya-chou the route taken was by raft down a tributary of the Yang-tse, then through the Yang-tse gorges to Ichang, and then by steamer, 900 miles, to Shanghai. Proceeding thence to Tien-tsin, the party were just in time to join the Peking relief expedition. On September 20, 1901, the author started again on a journey of some thousands of miles across Central to Western China. Captain Hunter, R.E., was his fellow-traveller, and each was accompanied by a surveyor and three Gurkhas. From Peking they travelled ninety miles by the French-Belgian controlled line, which is projected to run to the Yang-tse Valley at Han-kau, and is likely to have a great effect on the development and history of China, as it traverses some of the most populous and fertile districts of the empire. Trains were then running from Peking for 160 miles, and from Han-kau for 200 miles along the southern section. At Han-kau the line is connected with one from Canton in course of construction from materials being supplied by French, Belgian, and American firms. The author's party marched to Cheng-ting-Fu, fifty miles further, where evidence of foreign railway enterprise was again found. Many bridges would have to be constructed, the largest across the Yellow River itself at Yung-tse. There it was satisfactory to find evidence of British energy in a railway 700 miles distant from a seaport; but on crossing the Yellow River and reaching the city of Kai-feng-Fu, they found evidence of Continental enterprise, especially German. The Paper then gave a description of the province of Sechuan, with its 45,000,000 inhabitants and immense industries, and of the Red River Basin, with an area of nearly 80,000 square miles, and a population of over 40,000,000, the densest agricultural population in the world. Every foot of soil is under crops, including rice, wheat, millet, peas and beans, sugar-cane, and every sort of vegetable. In many places are brine wells, 2,000 feet deep, salt being a very valuable product in China. In other parts rich iron ore, copper, and quicksilver, and also gold, are found in great quantities. The author concluded by insisting on the importance of stimulating British enterprise in Central and Western China, pointing out what railways had done for British India, and expressing the opinion that far more might be expected from them in China, which had much greater resources and undeveloped wealth. China, too, possessed 400,000,000 of willing customers, whose industry, intelligence, and civilisation give them a high standard of comfort.

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6. *The Afforestation of Waterworks Catchment Areas.* *By* JOSEPH PARRY, *M.Inst.C.E.*[1]

The author described the causes that led to the neglect of forestry in this country and the pressing importance of the subject in view of the falling off in and increasing cost of foreign and colonial supplies, which have hitherto made up the deficiencies of home produce. The total imports of timber per annum amount to 10,104,504 tons, valued at 25,676,988*l.*, and the quantity of home-grown timber used in Great Britain and Ireland is estimated at 2,000,000 tons, being equal to about one-sixth the total consumption.

The Departmental Committee appointed last year by the Board of Agriculture made a recommendation—'That the attention of corporations and municipalities be drawn to the desirability of planting with trees the catchment areas of their water supply.'

The author estimated the total area of these catchment areas to be about 576,000 acres, of which at least 102,615 acres had been bought and were now

[1] The full paper will appear in the *Transactions of the Royal Scottish Arboricultural Society.*

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owned by the corporations. These lands are mostly in upland, thinly populated parts of the country, and excellently adapted for growing timber. The advantages of planting would be the preservation of the hill sides, the preservation of the purity of the water, and an increase in the total yield. At the same time it was claimed that afforestation conducted systematically and on scientific principles would be the most profitable use to which the lands could generally be applied. Stress was laid on the difference between planting for profit and ornamental planting, and the importance of working plans prepared by qualified experts was emphasised.

Particulars were given of the work done by the Liverpool Corporation on the watershed of Lake Vyrnwy, in Montgomeryshire.

The existing plantations around Lake Vyrnwy, old and new, cover 606 acres, and the total area of the watershed is 18,500 acres. Three nurseries have been established to enable planting to be carried on more rapidly in the future. Nearly 200,000 young trees now in the nurseries are to be planted out next season, and operations have already been commenced on that scale. The number of young trees required per acre is 2,700. The workmen employed in the woods reside off the watershed, and if they are engaged in operations near the head of the lake, which is nearly five miles long, they are carried in an oil launch. A sawmill for converting the timber into marketable sizes is now driven by steam power, but electric machinery driven by water power is being erected.

In the United States of America the importance of this subject is being recognised, and planting operations on a very extensive scale have been commenced both on waterworks catchment areas and in old forests which have been destroyed by fire and by the ravages of the lumbermen and farmers. These operations are under the direction of the Bureau of Forestry.

MONDAY, SEPTEMBER 14.

The following Papers were read:—

1. *Notes and Suggestions on Geographical Surveying suited to present requirements.*[1] *By* E. A. Reeves, *F.R.A.S.*

The paper points out in the first place that the advance of geographical exploration and discovery during recent years has been so rapid that there are now few parts of the earth's surface of which we have no knowledge whatever, although of many regions the best maps we possess are still extremely rough and inaccurate. The time has now come for replacing these approximate route maps of the pioneer explorers by more accurate surveys based upon scientific principles, without attempting the extreme accuracy of a large trigonometrical survey, for which, in many parts, we must necessarily wait for a long time yet.

It then briefly indicates the best methods of geographical surveying that might be followed, guided to a great extent by the course of instruction in geographical surveying arranged by the Royal Geographical Society.

After preliminary remarks as to the necessity of ascertaining what has already been done in the region to be visited, and as to whether any points have been definitely fixed which could be used as a basis for the survey, the author describes the best forms of the more important instruments required—the transit theodolite, plane-table, half chronometer watch, sextant and artificial horizon, barometer, &c. He then deals with the question of the most suitable scale and projection for plane-table work in the field, and in connection with the delineation of physical features on the map calls attention to the necessity of generalising and interpreting the leading characteristics of the physical features of a country, for which some previous training, not only in map drawing, but also in physical geography

[1] Printed *in extenso* in the *Geographical Journal*, January 1904.

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and the outlines of geomorphology, is a great assistance. Two methods of surveying are then described in outline, viz. (1) the extension of the triangulation by theodolite angles and the fixing of fresh points from those whose positions have been previously determined, or by latitudes and azimuths, detail being filled in with the plane-table; and (2) that in which no previously fixed points are available, and the surveyor has to determine the latitude and longitude of his stations from astronomical observations. The former should always be adopted where practicable. The most reliable methods, suitable for an ordinary geographical surveyor, by which the latter can be accomplished, are described, first as regards the fixing of latitude, and then of longitude. In connection with the fixing of longitude it is pointed out that it has been found practically impossible for a traveller to carry a watch or chronometer that can keep its rate sufficiently well for the determining of longitude with the accuracy that is now required, and recommends, where it is impossible to obtain Greenwich time without relying implicitly upon a watch—such as by telegraph or reference to some place of which the exact longitude is known—that differences of longitude only should be attempted, either by latitudes and azimuths or by using the watch for the meridian distance method. As regards the so-called 'absolute methods' of obtaining longitude, that by occultations of fixed stars is to be preferred. A few remarks follow on photographic surveying, and the necessity of the surveyor being able to draw his own map instead of merely furnishing the draughtsman at home with a rough and to a great extent unintelligible sketch, which is often the case.

In conclusion the author lays stress on the importance of travellers obtaining proper training in geographical surveying before starting on their journeys. He afterwards mentions that he has brought with him for inspection specimens of recent surveys of travellers, including a sample of the work done by one of his pupils for his examination for the Royal Geographical Society's diploma. He also exhibits a new form of clamp and tangent screw for sextant and other angular measuring instruments.

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2. *On Map Projections suited to general purposes.* *By* G. J. Morrison.

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3. *Henricus Glareanus (Sixteenth-century Geographer) and his recently discovered Maps.*[1] *By* Edward Heawood, *M.A.*

Heinrich Loriti, one of the most celebrated of the 'humanists' of the sixteenth century, better known by his territorial designation, Glareanus, was born in 1488, at Mollis, near Glarus in Switzerland. His title to fame rests principally on his many-sided contributions to knowledge in the field of literature, philology, mathematics, music, &c.; but he is known also as the writer of a work on geography which passed through many editions from 1527 onwards. In this he described, for the first time, so far as is known, a convenient method of constructing gores for a globe, which was much used in his time, though as examples of such gores are known from considerably earlier than 1527, some doubt has been expressed whether he was the actual inventor of the method. Coloured manuscript maps from his hand have within recent years been discovered in copies of printed works at the libraries of Munich and Bonn Universities, and have attracted some attention from the fact that they were, according to their author's statement, based upon the long-lost map of Martin Waldseemüller, which has itself been discovered since. One of the maps was also interesting as the earliest known representation of a hemisphere on an equidistant polar projection.

At the time of the Elizabethan Exhibition, organised by the R.G.S. early in 1903, a volume of early MSS. was sent in which at once attracted attention from the fact that the first item, though without a contemporary statement of the author's name, was stated in a note by a former owner to be by Henricus Glareanus. Further inspection showed that the handwriting was identical with that

[1] Will be printed *in extenso* in the *Geographical Journal*.

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on the margins of the Bonn maps, and that the MS. was that of the treatise on geography published in 1527, but that it included a fine coloured set of unpublished maps, closely resembling those at Bonn and Munich, but more in number and somewhat more carefully executed. Particularly interesting was the fact that a pair of the maps were evidently copies of the famous map of Johan Ruysch issued with the Rome Ptolemy of 1508, while both the northern and southern hemispheres were shown on an equal scale on the equidistant projection, the southern having been given on a much reduced scale, and with the continental outlines reversed, in the Bonn copy. Examination showed that the MS. was the original MS. of the work (many alterations and marginal additions made on it having been incorporated in the printed edition), but not the copy from which the printer had worked, as further corrections and additions appear in the printed volume. From the great resemblance of the maps to those at Bonn, which were made in 1510, and the fact that Glareanus was in correspondence with the Swiss reformer, Zwingli, on the subject of geographical studies in the same year, it seemed probable that the treatise was first written considerably before 1527, and this idea is supported by the nature of the additions made in the printed work, which include references to the 'eruditus rex' Henry VIII. of England (whose reputation for learning would have reached Glareanus at an early date, through the latter's correspondence with Erasmus), and to his residence as professor at Paris, which came to an end in 1521. In this case the existence of gores drawn after his method in about 1515 would be explained, while in various ways the claim of Glareanus to originality as a geographer would be heightened, his work being *ex.* prior to the well-known treatise of Apianus, which first appeared in 1524. It may be noted that one of the editions of the smaller Cosmography, generally attributed to Apianus, incorporates bodily one of the chapters of Glareanus's work.

The history of the MS. is of interest, as its private ownership can be traced back some 300 years to a member of the important Swiss family of Ott, from which the present owner, Major-General E. Renouard James, is descended in the female line through that of Renouard. Among the other documents contained in the volume is a letter from Erasmus to Glareanus, written in 1516, but this throws no light on the subject of the geographical work of the latter. Some or all of the maps may possibly be reproduced in coloured facsimile by the R.G.S. if sufficient subscribers appear likely to come forward.

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4. *The Results of the Expedition to Sokotra and Abd-el-Kuri by Mr. W. O. Grant and Dr. H. O. Forbes.* *By* H. O. FORBES, *LL.D.*

At the meeting of the Association at Bristol in 1898 a committee, consisting of Dr. Scott Keltie, Dr. Blanford, Professor Weldon, and the author, was appointed to further an expedition then projected by Mr. W. O. Grant (of the British Museum) and the author, for the exploration of the islands of Sokotra and Abd-el-Kuri, situated in the Gulf of Aden, and a sum of money was placed at their disposal in aid of the project. The Councils of the Royal Society and the Royal Geographical Society also generously assisted the expedition by grants of money and instruments, while the Museums Committee of the Liverpool Corporation gave substantial aid in money and by allowing the chief taxidermist of the Museum to accompany the expedition. The Museums Committee undertook in addition the publication of the results in a special volume of the 'Bulletin of the Museums,' the quarterly periodical of these institutions. The expedition left England in October 1898 and returned in March 1899. A preliminary report was presented to this Association at the Dover meeting. Since then the results of the expedition have been worked out and a volume containing 600 pages, thirty-four coloured plates, and eighty-eight illustrations in the text was placed on the table. As editor of it the author had the good fortune to have the co-operation of twenty distinguished specialists (in addition to the contributions by Mr. Grant and himself) in working out the collections. The objects of the expedition were biological (mainly) and geographical. The volume as

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ssued is practically a zoological monograph of the islands. A large number of plane-table and theodolite observations were made, and many anthropological data collected. A large scale-map was in process of construction from the plane-able sheets when these and the instruments which were being employed in the work were purloined during repairs to the author's house by some unknown workman. Their loss was not detected for some weeks, but since then every effort has been made—not yet hopelessly—to recover them; in the meantime it is impossible to proceed further with the construction of the map. As the inclusion of the historical and anthropological data would have rendered the volume too bulky, they have been reserved for publication elsewhere.

No new mammals were obtained by the expedition, but specimens of the interesting wild ass, which proves to be the Nubian and not the Somaliland species, were obtained. The domestic cattle, a very beautiful diminutive breed, would seem to be here a long-isolated colony of the *Bos longifrons*, introduced probably from Egypt before the Christian era. Sixty-eight species of birds are now known from Sokotra, of which the expedition added ten species, four of them new to science and six not previously known to live there. From Abd-el-Kuri, from which no collections had previously been brought, twenty-two species, three of them new to science, have been recorded. Of reptiles, Mr. Boulenger has enumerated twenty-eight species, of which seven are new. Mr. E. A. Smith has described sixteen new species of Mollusca, and Mr. Pocock eighteen of spiders and scorpions. Six species of Crustacea are reckoned as new by Mr. A. O. Walker in quite a small shore-collection from Abd-el-Kuri. Among the Insecta a large number have proved to be new endemic species. Mr. Kirby has described twenty-seven among the Hymenoptera, Mr. Gahan twenty Coleoptera; Mr. Grant, Lord Walsingham, and Sir George Hampson have enumerated twenty-seven Lepidoptera, Miss Ricardo twelve Diptera, Mr. Maclachlan three Nemoptera, and Mr. Burr six Orthoptera. Mr. Pocock has described five new Myriapoda. Professor I. Bayley Balfour undertook the examination of the botanical specimens, which consisted of living plants, bulbs, tubers, seeds, and Herbarium. Little new was to be expected among these after the thorough manner he had himself investigated the island; but he has found they include four species new to science, and six, otherwise known, new to the flora. The whole of the plants from Abd-el-Kuri—seventy-eight in number—are recorded here for the first time, and of these three are new to science, and all but six occur on Sokotra.

The geology, as illustrated by the specimens collected by the expedition in these two islands, has been described by Professor Gregory.

In all, over 150 species have been added to the zoology of the islands.

In conclusion, the institutions concerned in the expedition desire to express their warmest thanks to the Council of the British Association as well as to the Royal Society and the Royal Geographical Society for the assistance and encouragement they gave to the expedition.

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5. *On the Origin of Adam's Bridge.* *By* J. Lomas, *A.R.C.S., F.G.S*

Stretching across from the north part of Ceylon to the south-east coast of India lies a remarkable chain of low-lying islands and shallow banks known as Adam's Bridge. Rameswaram Island forms the most westerly link of the chain and is only separated from Tonitoray Spit (India) by Pambam Straits, a shallow natural opening which has been deepened in parts by man. Manaar Island, at the extreme east of the bridge, lies close to the north-west coast of Ceylon. Between these a number of smaller islands complete the chain. North of Adam's Bridge extends Palk Bay, a shallow mud-floored almost currentless sea, and to the south the Gulf of Manaar stretches as a low platform, deepening fairly evenly to the south at about the rate of one fathom in two miles to twenty fathoms, after which it sinks more rapidly to great depths. The platform consists of sands, which in places have been cemented *in situ* into calcareous sandstones or calcretes chiefly by the agency of Polyzoa and Nullipores. These masses of solid rock, known as 'paars,' are

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sometimes accompanied by coral reefs in all stages of decay, from the living forms to almost structureless limestone.

In places along the west coast of Ceylon spits of sand stretch across the platform mainly near the mouths of rivers. They result from the detritus brought down by rivers, and their general trend to the north-west may be due to the combined flow of the streams and the prevailing inshore currents on the Indian side, and in Palk Bay rivers form similar spits of sand which extend towards the north-east. The coasts of India and Ceylon are swept by strong marine currents running up or down the coast according to the monsoons, but owing to the longer duration of the south-west monsoon this produces greater effects, and all rivers flowing into the gulf have a tendency to extend their deltas towards the north. Near the coasts the spits consist of coarse fragments, while further out the sands become successively of finer grain. Long-continued growth of these spits would result in the formation of a platform arching to north. The rocky 'paars' arrange themselves roughly into three groups running parallel with Adam's Bridge. The first line is found at a depth of 3½–4½ fathoms, the second at 6–8 fathoms, and the third at 9–10 fathoms. If an area of this character were raised above the sea level we should expect the harder 'paars' and limestones to exist as islands, between which would be areas of loose drifting sand.

Such is exactly the structure of Adam's Bridge. Rameswaram Island has an ancient coral reef along its northern border, but the bulk of the island, as well as the others constituting the bridge, are composed of calcareous sandstones, like those now forming in the 'paars.' Similar sandstones are found all along the east coast of India from Cape Comorin to Madras, and are represented on the west coast by the 'littoral concretes' which are considered by Oldham to have been originally sand spits or beach deposits. All these contain none but recent shells exactly like those living in the neighbouring seas. As no rocks of undoubted Tertiary age are found on the adjacent coasts, it would appear that all through that period the district has been in a state of equilibrium. Since Miocene times there has been no break in the deposition of material, the new beds quietly overlapping the older. In the absence of any signs of tectonic movements during the Tertiary period we are driven to the conclusion that the shallow platform in the north part of the Gulf of Manaar is due to the filling up of the sea by the *débris* derived from the land. Suess attributes the emergence of Adam's Bridge and the 'littoral concretes' to a negative eustatic movement of the sea level in post-Tertiary times. This may have been so recent that the great Hindu epic, the 'Ramayana,' which treats of the building of Adam's Bridge, may be a poetical rendering of events witnessed by man. Although we have no certain evidence that the Bridge was at any time continuous, we have historic data to prove that the island of Rameswaram was once united with Tonitoray Spit.

If, as I suggest, the various links in the chain of islands represent emerged 'paars,' we have no reason to suppose, judging from the distribution of those now forming, that they were ever united.

The following Paper was read to open a Discussion on the Teaching of Geography (joint meeting with Section L):—

6. *Geographical Education.* *By* H. J. Mackinder.

Classics and mathematics are effective educational disciplines largely because, as the result of long experience, they can be taught by methods which are progressive from the lower to the higher forms of a school. If geography is to be generally utilised in secondary education, it must become similarly *progressive* rather than merely cumulative of facts. In practice this implies the fulfilment of three conditions:—

(1) That the pupils be classed in special 'sets' for geography, lest they omit stages in the argument;

(2) that the master know the subject thoroughly; and

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(3) that the public examinations be based on some generally accepted sequence of exposition, as in the case of languages and mathematics.

It would probably be hopeless to expect a general fulfilment of the first two conditions unless the third be practicable. It is well, therefore, to concentrate attention upon this.

The phenomena of geography are capable of arrangement upon alternative principles, either according to regions or according to categories. In the one case the chapter-headings of a text-book would be such as 'France,' 'India,' &c.; in the other they would be such as 'volcanoes,' 'climates,' &c. The former is spoken of as regional geography, the latter as general, or commonly, but unfortunately, as physical geography. In the university the general classification may often be advisable, but in the school it is submitted that the *regional* basis should in the main be adhered to, for distribution is of the essence of geography and imparts to regional geography a unity not possessed by physical geography. Indeed the latter might be described as a series of chapters treating of the geographical aspects of other sciences—astronomy, geology, meteorology, botany, zoology, anthropology, strategy, economics, and history. The separation of school geography into two subjects, topography and physical geography, has probably done more than anything else to arrest its development as a discipline.

It is suggested that it would be quite possible to weave into the regional treatment so much as is needed of other sciences by taking these in *one at a time* in the successive stages of the strictly geographical argument. This idea will be most easily conveyed by sketching a possible course of instruction. Let it be divided into six stages, of which the first will be elementary, the next four secondary, and the last higher.

Stage 1 (elementary).—It is agreed on all hands that the teaching of geography should commence with the home. This, however, involves among other things the observation of the apparent movements of the sun and stars, and hence their explanation by means of the globe. The lie and names of the continents and oceans would also be learnt upon the globe, and some idea of their chief contrasts won from the reading of simple stories of discovery, adventure, and travel, the teacher everywhere asking the pupil to contrast with the home conditions.[1]

Stage 2 (ages thirteen and fourteen).—This, which is usually omitted, should have for subject such a wider 'home area' as would permit of the study of entire river basins, water partings, coast and hill forms, &c. The real study of the use of maps as opposed to mere plans and sketch maps would commence here, and this would be the approximate stage for the introduction of such ideas as the deposition, folding, faulting, and sculpture of rock strata as explanatory of the surface forms.

Stage 3 (ages fourteen and fifteen).—Here the 'home country,' the British Isles, would be considered as a whole. The land-forms and essentials of structure would be quickly yet accurately conveyed by the use of the ideas and terms learnt in Stage 2, and time would thus be available for a thorough explanation of the climatic contrasts; a subject unsuited to Stage 2 by reason of the limitation of the area then studied. Moreover the teaching of elementary physics by the science master would at about this stage render the fundamental ideas involved more easily appreciable.

Stage 4 (ages fifteen and sixteen).—Here we come to the comparison of the home country with the great civilised countries of Europe. The physical facts, both morphological and climatic, would be conveyed quickly yet accurately by means of the ideas and terms learnt in Stages 2 and 3, and special stress would now be given to the political and economical facts. The pupils would be ready for these by reason both of their progress in history and of their increasing interest in the newspapers. Care would be taken to correlate the political with the physical. Problems and essays would be set.

Stage 5 (ages sixteen and seventeen).—This would be devoted to the study

[1] In the case of children not proceeding to secondary schools selected portions of Stages 2 and 3 must be taken in the latter part of the elementary training.

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of the whole globe, especially outside Europe. It might include more accurate astronomical ideas (*cf.* Stage 1), for which the pupils would have become fitted by reason of their mathematical studies; also the leading facts conditioning plant-life. Both of these contributions would be pertinent to the treatment of climates. The history of discovery (*cf.* Stage 1) would be utilised in explaining the chief place-names. The pupils would by this time have accumulated a considerable background of knowledge which would be appealed to. The increasing wealth and variety of the data would necessitate firm grip on principles and a logical method. Therefore a specialist teacher would be advisable in order to obtain mental discipline, just as a classical sixth form requires a composition master.

Stage 6 (university and college).—Here we should naturally find both deeper intension and wider extension. By the adoption in part of the general classification—*i.e.*, by the study of the distribution of particular types of phenomena—the student would become critical and be prepared for original research. On the other hand, by the complementary effort to construct an harmonious regional geography out of a great series of varied data he would be inspired with a broad and philosophical outlook.

Nowhere is the contrast between the general and the regional method more conspicuous than in the treatment of the wind system. The temptation is great to commence deductively from an imaginary landless globe. But this is essentially unsound because it implants wrong and unscientific habits of thought. The trade winds, for instance, should first be learnt of and *realised as a great fact* in the description of the North Atlantic, the complementary wind being added in the description of the South Atlantic. The double system would then be found again in the Pacific and a generalisation demanded by the pupil which would presently be limited by the facts of the Indian Ocean. The Sahara Desert would carry the generalisation a step further and into apparently different phenomena. Only in the end would deduction from ideal zones or belts of climate be permitted by way of mental stocktaking.

The criticism of the practical teacher for such a scheme as is here outlined would probably be grounded on limitations of time. It is submitted that with the pupils in geographical sets, specialist teachers, and agreement as to examination bases, very much might be accomplished even with the hours now usually available. At the risk, however, of appearing visionary it is further submitted that those hours should be extended on the ground that geography is one of six elements needed in any liberal as opposed to technical education. These elements are:—

(1) Language, with reading and writing as its implements, and the mother, the foreign, and the dead tongues as its varieties.
(2) Mathematics, or training in abstract thought.
(3) Experimental science, or training in thought about concrete things.
(4) History, or outlook through the time covered by human records.
(5) Geography, or outlook through the space accessible to men.
(6) Religion and philosophy.

It is submitted that the inclusion of these six elements in a general education is more essential than the study of several varieties of any one, *e.g.*, several languages or several sciences.

Apart, however, from any such theoretical argument, it is claimed that geographical teaching, if it deals with real conceptions and not merely names, trains in the mind a distinct power, that of thinking in terms of the map, of visualising intricate correlations, of ordering complex masses of fact—a power of the utmost value in the practical affairs of after-life. Geography rightly taught should tend to correct the academic bias of linguistic and mathematical study, the specialist bias of scientific study, and the archaic or sentimental bias of historical study. Its danger lies obviously in superficial knowledge and uncritical thought. Taught in the past too often by those who knew little of it, geography has no doubt deserved its inferior position among educational disciplines.

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Finally it is submitted that geography can be placed in its rightful position only by the simultaneous application of a fourfold policy:—

(1) The encouragement of university schools of geography where geographers shall be made, of whom many will become secondary teachers.

(2) The appointment of trained geographers as teachers in our secondary schools, either for geography alone or for geography and general help in other subjects.

(3) The general acceptance of a progression of method in the subject, not expressed in detailed syllabuses issued by the State or other dominant authority, which would tend to stereotype teaching, but in a tradition similar to that which at different times has governed the teaching of language and mathematics.

(4) The setting of examinations by expert geographical teachers.

It is obvious that these four measures must be applied simultaneously, for schools will not appoint specialist teachers unless there is a supply of them to select from; and yet a supply will not be forthcoming unless there be a promise of posts, nor is the teacher independent of the examiner or yet of the general esteem of his subject based on a belief in the value of its methods.

An Ounce of Fact.—The adoption of a new syllabus for geography in the London Matriculation and of geography as an obligatory subject in the Intermediate Examination of the Faculty of Economics and Commerce, coupled with the appointment of a holder of the diploma of the Oxford School of Geography as teacher of the subject at University College School, London, has contributed to results which are patent in the Pass List issued last month by the London University.

TUESDAY, SEPTEMBER 15.

The following Papers were read:—

1. *On the Relation and Importance of Botany to Geographical Science.* *By* Dr. Otto V. Darbishire.

Plants play a very important part in the composition of the scenery of our earth. So much is this the case that a barren desert strikes us as remarkable, chiefly on account of the absence of any vegetation.

The professional geographer and traveller has generally at most only a very slight acquaintance with any branch of botany. The problem before us is, Would an acquaintance with certain branches of botany be of any scientific interest or practical value to the geographer?

Botany and geography meet on common ground in the following branches of botany:—

(*a*) The geographical distribution of plant species. The distribution of plants when grouped according to their natural affinities into natural orders, genera, or species is seen to depend very generally on the distribution of temperature over the earth's surface, without reference as a rule to local conditions.

(*b*) The geographical distribution of plant forms, or ecology. The plant form is an expression of the way in which the plant body has adapted itself directly to the external conditions under which the plant is living. It affords, therefore, to a certain extent, an indication of what these conditions are. An association of similar plant forms is called a formation. The presence of any of the three chief kinds of formation, namely, forest land, grass land, and desert land, depends almost entirely on the relation existing between the supply of water available for absorption by the plant root and the amount of water given off by the plant shoot. The preponderating influence may be due to the climate (climatic formation) or the soil (edaphic formation). Temperature generally has no hand in the making of the plant form.

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(*c*) The influence of the plant world on the earth's surface. Most sub-aerial plants penetrate into the soil for purposes of attachment or absorption of food material. Their action may be a physical one only, or a chemical one in addition. Plants are as often responsible for the first crumbling away of the solid rock as for the binding together of loose soil.

These three subjects are of great interest to the geographer, but ecology is in addition of the greatest importance to the traveller.

Ecology teaches the traveller how to analyse and classify the forms of vegetation met with. He is enabled through it to make out many of the prevailing conditions by reference to the plant forms observed. He is also enabled to give a scientifically accurate account of what he has seen, because he understands the relation existing between the plants and the conditions under which they are living. A knowledge of ecology should, in fact, be considered a most necessary part of the scientific equipment of any professional traveller.

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2. *The Observation of Features of Vegetation in Geographical Exploration.* *By* Dr. W. G. Smith.

Descriptions or even notes on vegetation are not a feature in the majority of papers in English relating to travel and exploration. Yet the vegetation of a country is, after the configuration, the most important factor in a landscape. There are in existing books and papers descriptions of vegetation which show that these can be made, and that thereby the utility of the observations is greatly extended, not only from an economic aspect, but also in the direction of plant geography. Considerable progress has been made towards representing the vegetation of a country on maps. This is done by recording the limits of distribution of the most abundant (or dominant) plants, such as trees; and already the vegetation of considerable tracts of Britain, Europe, and North America has been charted. The detail in simple cases shows the region of deciduous trees as distinct from that of coniferous trees, and the forest lands as contrasted with treeless. Or greater detail may be shown, as in the series of maps now being issued in Britain.

Vegetation charts of all parts of the earth would be a distinct gain to plant geography. The scope of such a survey for any area would depend on the maps available and on the observer's knowledge of plants. In the case of a party which included a botanist and traversed a country with fairly complete maps there should be considerable opportunity of ascertaining and recording the limits of important dominant plants. Such a survey, accompanied by the collecting of plants, would furnish material of great value. In the case of an expedition in an area poorly charted there would still be opportunities of collecting fragmentary evidence regarding vegetation. Notes on the dominant plants could be made at places where geographical observations were taken, and where a change occurred from one type of vegetation to another the limit could be ascertained with as much accuracy as possible. Even in a case where the dominant plants were unknown to the observer a small collection of them labelled by numbers for reference could be afterwards identified. An acquaintance with the methods of botanical survey followed in Britain and elsewhere would be a useful preliminary for intending travellers.

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3. *Botanical Survey of the Basins of the Rivers Eden, Tees, Tyne, and Wear.* *By* Francis J. Lewis, *F.L.S.*

The survey was begun during the summer of 1900, and had for its object the mapping of the various plant associations and observations on the different factors governing their distribution.

The whole of the work has been done with the aid of the 6-inch Ordnance maps, the boundaries of the different associations as observed in the field being drawn on these, and subsequently reduced on to smaller scale maps.

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The salient features of the vegetation may be summarised as follows:—

The region of cultivation is very restricted, and chiefly confined to altitudes below 1,000 feet, and the greater part of it is under permanent pasture, although cultivation with oats is carried on below 800 feet.

The region of woodland is poorly represented, and may be divided into (1) oak woods, (2) coniferous woods, (3) birch woods. The oak woods occur only below 800 feet, and coniferous and birch woods only in a few instances reach an elevation of 1,000 feet.

An examination of the peat on the higher fells shows that the ground has not always been of its present treeless nature. Remains of birch, alder, and poplar may frequently be discovered buried about 16 or 18 feet down in the peat, and the author has observed extensive remains of birch as high as 2,400 feet, being higher than it grows anywhere in Great Britain at the present time. Remains of pine also occur as high as 2,600 feet on Cross Fell. Sections are being made through the peat in areas now covered by heather moors, *Eriophorum* bogs and *Sphagnum* bogs, and sufficient evidence has been collected from these sections to show that nearly the whole of the high-lying watersheds of the Tees, Tyne, and Wear have at some former time been covered with extensive woods of birch and pine.

Pasture associations are chiefly represented by grass heaths dominated by either *Nardus stricta* or *Molinia varia*, according as they occur in well-drained or wet situations. The natural pasture is limited to outcrops of limestone free from peat, and is generally met with in narrow bands or patches, sometimes occurring in the midst of extensive grass heaths or heather areas. The heather associations reach their greatest development in the Mickle Fell district on limestone covered with peat. The Stainmore district, to the south of this, consists of sandstones, grits, and shales, and the chief associations here are *Eriophorum* bogs and *Sphagnum* bogs. These associations also attain a great development on the sandstones and shales of the Wear watershed.

The chief artificial agency at work tending to modify the vegetation in some places appears to be overstocking with sheep, the constant browsing, treading, and manuring tending to kill the natural heather vegetation. Under these circumstances the heather area in a badly drained situation may be changed into an *Eriophorum* bog, and in a dry, well-drained position into a poor grass heath chiefly dominated by *Nardus stricta* and *Juncus squarrosus*.

A detailed account of this survey, with maps, will be published in the 'Geographical Journal,' and the author hopes to extend the area of observation northward to the Cheviots and westward to the coast covering the northern portion of the Lake District.

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4. *Peat Moors of the Southern Pennines: their Age and Origin.* By C. E. Moss, *B.Sc.*

The present condition of these moors is first considered, and the author classifies them as (i.) Cotton-grass Moors, (ii.) Heather Moors, and (iii.) Grassy Moors. The question as to whether or not the Pennines were prehistorically tree-clad is next discussed, and evidence is considered from (i.) history, (ii.) place-names, (iii.) buried timber, (iv.) neolithic flints, and (v.) present range of British forest trees. The conclusion is arrived at that, though the Pennine slopes were tree-clad so late as Saxon and Danish times, yet at that period the summits were covered with an extensive morass. This morass was caused by the destruction or decay of forests which existed on the Pennine summits so late probably as the Roman period.

In order to check the estimate suggested by the above conclusions the mode and rate of formation of peat are considered. The author discusses (i.) the rapid formation and (ii.) the slow formation of peat, and (iii.) the plants which form peat at the present time; and he considers that as a rule the peat moors of the Pennines cannot date to a period further back than about two thousand years. The paper concludes with remarks on the possible utilisation of the Pennine peat moors.

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5. *Queensland.*[1] *By* J. P. THOMSON.

After a brief allusion to some of the main landmarks in the history of Queensland the paper proceeds to give a general sketch of the physical features of the State, describing its mountain and river systems and the three great natural regions into which it may be subdivided on physical and climatic grounds. These are (1) the eastern division, lying between the coast and the great dividing range, consisting of well-watered fertile lands clothed in the northern part with vegetation of unsurpassed luxuriance; (2) the watershed of the Gulf of Carpentaria, wholly tropical, but mainly adapted rather for pastoral than agricultural purposes; and (3) the vast western district, embracing the famous downs country, unsurpassed for richness of soil and magnificence of climate, the only drawback being the uncertain and scanty rainfall, the want of which is, however, to some extent supplied by its artesian resources. The geological structure, in regard to which an entire difference is noticeable between the east and the west of the State, is next comprehensively described, attention being paid to the influence of geological facts on the possibilities of artesian development. The mineral wealth—consisting primarily of gold, but including copper, silver, antimony, and tin ores; coal, opal, gems, bismuth, wolfram, manganese, and lead—is described as practically inexhaustible, and an account is given of the most valuable deposits yet exploited. The main characters of the flora and fauna are next described, special attention being paid to the products of most economic importance. In describing the climate of Queensland the author points out the special advantages possessed by the southern districts and the curative properties of the dry and buoyant air of the western plains. The distribution of the rainfall is discussed, and details are given of the artesian water supply which supplements this in the interior districts. Possibilities of storage of river water for irrigation are also touched upon. Coming next to the industrial resources of Queensland, the author points out the unrivalled advantages given by its position with regard to the great commercial highways of the East, its fine natural harbours and its coast protected from the ocean by the Great Barrier reef. The present population is but a fraction of that needed for its satisfactory development, and the immigration of Polynesians is a necessity for the cultivation of the tropical portion. At present the pastoral industry is more fully developed than either mining or agriculture, the sheep, cattle, and horses numbering some scores of millions when not handicapped by droughts. The agricultural industry is at present limited to the eastern settled district from Cookstown south, but with irrigation the rich western region might produce immense quantities of grain. In addition to sugar the coast region produces maize, tobacco, coffee, cotton, arrowroot, &c., and fruit-growing might be taken up with profit. The great need is an enormously larger population to settle on the land and develop its vast resources.

[1] The scientific matter will be published in the *Geographical Journal.*

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SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

PRESIDENT OF THE SECTION—EDWARD W. BRABROOK, C.B.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

IT is a coincidence, which has great interest for me personally, that the honour of being President of this Section has fallen to me in the last year of my engagement in the public service. I am now in the sixty-fifth year of my age and the thirty-fifth of my connection with the Registry of Friendly Societies, and in a few months the guillotine of the Order in Council will fall, and the Department and its present head will be severed. The consequences are not so tragic as they sound, for the Department will at once find a new head, and the old head will contrive to maintain a separate existence. I therefore meet the stroke of fate with cheerfulness; for I am strongly of opinion that the arrangements for retirement from the Civil Service of the country are as wise as they are liberal. It is a good thing that the place of a man whose ideas have grown old and become fixed, and whose long service indisposes him to entertain new ones, should be taken by a younger man anxious to make his own mark on the administration of his department. Again, the prospect of promotion opened up by the limited term of service of the older men is a distinct inducement to able and ambitious young men to devote themselves to their country's service. I have lately had occasion to give minute and careful attention to one branch of this important question, and the study of the whole subject which has thus been rendered necessary has strongly confirmed the conviction I previously entertained that the system of retirement which now prevails greatly tends to promote the efficiency of the Civil Service and the interests of the country. I do not apologise for saying this much on a subject into which I was led by an observation that concerns me personally, for the means of securing efficiency in the public service is an important economic question.

The coincidence to which I refer tempts me to choose as the principal subject of the Address which I am permitted and enjoined to deliver to the Section on this occasion that small corner of the great field of Economics in which I have been a day labourer for so long, and I am not able to resist the temptation. My piece of allotment ground, if I may so call it, is that which is devoted to the cultivation of thrift, or of economy in the popular rather than the scientific sense. The temptation is strengthened by the circumstance that that subject has rarely been treated by my predecessors. Sir Robert Giffen in his Address of 1887 referred to it, and Sir Charles Fremantle in 1892 treated it at somewhat greater length. In old times, when the Chair of this Section was more frequently occupied by the practical statesman than by the professed economist, there were passing allusions to it by Henry Fawcett in 1872, William Edward Forster in 1873, and Sir Richard Temple in 1884; but in more recent years the accomplished economists who

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have presided over this Section, notably my immediate predecessor, have delivered luminous and memorable Addresses on the broad principles of Economics, the application and potency of its doctrines, and their serviceableness to mankind, with a comprehensiveness of view that is only attainable as the result of deep study, and a brilliancy of exposition that belongs to philosophic insight. I may here, in passing, express the satisfaction we all feel that at Cambridge, where we are to meet next year, proficiency in Economics and Political Science is now fully recognised as qualifying for academical honours.

I have spoken of the subject of Thrift as a small corner of the great field of Economics; and relatively to the broad field itself it is so; but it is a subject that deals with large figures and intimately affects large numbers of people. The 2,000 Building Societies in Great Britain and Ireland have 600,000 members and sixty-two millions of funds; the 28,000 bodies registered under the Friendly Societies Act have 12,000,000 members and forty-three millions of funds; the 2,000 co-operative societies have 2,000,000 members and forty millions of funds; the 600 trade unions have more than a million and a half members and nearly five millions of funds; in the 13,000 Post Office and other savings banks there are more than 10,000,000 depositors and more than 200 millions invested; so that upon the whole in nearly 50,000 thrift organisations with which the Registry of Friendly Societies has, in one form or other, to deal there are twenty-seven millions of persons interested and 360 millions of money engaged. These figures, however, possess no significance other than that they are very big. Many individuals are necessarily counted more than once, as belonging to more than one society in one class, or to more than one class of societies. Some portion of the funds of Friendly Societies is invested in savings banks, and therefore is counted twice over. Some of the co-operative societies, as, for example, the wholesale societies, have for capital the contributions of other societies, which thus are also counted twice over. On the other hand, the aggregate, large as it is, is necessarily defective. It includes only bodies which are brought into relation with the Registry of Friendly Societies in one or other of the functions exercised by that department. It does not include, therefore, many co-operative and other bodies which are registered under the Companies Act, nor the Industrial Assurance Companies which are regulated by the Assurance Companies Act, nor does it include the great body of Friendly Societies which are not registered at all. Among these shop clubs hold a prominent position, and these are very numerous. The Royal Commissioners of thirty years ago thought that the unregistered were then commensurate with the registered bodies; and as one result of the legislation which the Commissioners recommended has been to diminish the applications for registry made by such societies as are subjected by it to the necessity of a periodical valuation of assets and liabilities, there seems no reason to think that unregistered societies are relatively now any fewer than they were then.

It would seem, then, that the figures we have cited are well within the mark, and that, used for the mere purpose of indicating the magnitude of the interests involved, they may be relied upon as not over-estimating it. The observation just made leads to the question, why should there be so many unregistered societies? Why, indeed, should there be any unregistered societies? The National Conference of Friendly Societies, which consists wholly of registered bodies, has just passed a resolution recommending the enactment of a law that all societies should be compelled to register. Why not? I think it will not be difficult to find the real answer to these questions. It was given as long ago as 1825 by a Committee of the House of Commons in these wise words:—'It is only in consideration of advantages conferred by law that any restrictive interference can be justified with voluntary associations established for lawful and innocent purposes. It is for the individuals themselves to determine whether to adopt the provisions of the statute, which offers them at the same time regulation and privilege, or to remain perfectly unfettered by anything but their own will, and the common or more ancient law against fraud or embezzlement,' which common or more ancient law was strengthened in 1868 by the Act known as Russell Gurney's Act. 'For your Committee apprehend that although the Act

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of 1793 appears to begin by rendering lawful the institution of Friendly Societies, there neither was at that time nor is now any law or statute which deprives the King's subjects of the right of associating themselves for mutual support.'

Upon this principle the Legislature has hitherto proceeded. Registration is voluntary. The subscriptions of the members are voluntary. The conditions of membership are such as the rules framed by the members themselves impose. They have full authority to alter those rules from time to time. Those conditions may, if the members so please, imply that the subscriptions are to be small and the benefits large. They may provide for investment of funds on any security they think fit so long as it is not personal security. They may provide for the periodical division of the funds so long as they make it clear that all claims existing at the time of division are first to be met. Up to this point the registered society and the unregistered are hardly distinguishable. What, then, are the obligations consequent upon registry? There is the making an annual return and the making a quinquennial valuation; but the action to be taken by the society upon the result of the valuation is wholly in the discretion of the members. The valuer may demonstrate beyond doubt that the society in order to save itself from disaster must increase the subscriptions of the members or diminish their benefits; but neither he nor the Registrar can enforce the recommendation. The society has its destinies wholly in its own hands. Then, again, the Act contains certain provisions for the protection of members. Individual members have the right to inspect the books of the society, to receive copies of its balance-sheets and valuations, and so forth. A certain number of the members have the right to apply to the Registrar to appoint an inspector into the affairs of the society or to call a special meeting of the members. The inspector can only report—there is no action which the Registrar can take upon his report if the members disregard it. The special meeting will in no way differ from an ordinary meeting called by the society itself, except that it may choose its own chairman. The Registrar cannot in any way control its proceedings. Even these things he cannot do of his own motion without being set in action by a competent number of the members. If a society becomes insolvent, members may in like manner apply to him to wind it up: he may see that a readjustment of contributions and benefits would set the society on its legs again, and may suspend his award of dissolution to enable the society to make that readjustment, but he can do no more. If the society refuse to make it, he has no option but at the end of the period of suspension to issue the award. Here again he may have the fullest knowledge that a society is hopelessly insolvent, yet he can do nothing unless a competent number of the members call in his aid. I confess that I think the Legislature might have gone further in this respect and conferred upon the Registrar, or at any rate upon some public authority, the power to deal compulsorily with cases of hopeless insolvency, and if necessary to appoint a receiver, as such cases are not infrequently complicated with fraud carried on in circumstances which make it difficult for a competent number of the members to join in an application to the Registrar. However that may be, taking the legislation as it stands, it embodies to the fullest extent the principle laid down by the Committee of 1825.

The surrender of freedom which a Friendly Society is called upon to make in order to obtain the privileges of registry, which are not inconsiderable, is therefore exceedingly small; yet it is sufficient, as we have seen, to keep out of the registry office a large number of societies. It seems not improbable, looking back on the history of legislation on the subject—and the observation is a curious one—that unwillingness to register has been closely connected with actuarial considerations. Thus, in the year 1819, an Act was passed which provided, among other things, that the justices should not confirm any tables or rules connected with calculation until they had been approved by two persons at least known to be professional actuaries or persons skilled in calculation; but that was repealed in 1829. Again, in 1846 an Act was passed which provided, among other things, that every registered society should make a quinquennial valuation; but that was repealed in 1850 before a single quinquennial period had arrived. It was not till a quarter of a century after 1850 that this most salutary provision again found a place in

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the statute book, and the experience of the last twenty-eight years has shown how valuable it is, and how much it is to be regretted that the Act of 1846 was not allowed to remain in force. Again, the Act of 1850 provided for the discrimination of societies into two classes: those which were simply registered and those which were certified. These latter were to obtain the certificate of a qualified actuary that their tables of contribution were sufficient for the benefits they proposed to insure. Very few certified societies were established, and that Act was repealed in 1855. The experience of the Legislature has not been favourable therefore to endeavours to impose upon Friendly Societies by Act of Parliament conditions of actuarial soundness.

If, however, the voluntary principle is abandoned, and all societies are to be compelled to register, it is obvious that there must be a recurrence to the policy of imposing such conditions. At present a registered society may be as unsound as it pleases, and so may an unregistered society. Unless registry is to imply something more than that, there can be no reason for any compulsion to register. For what does compulsion mean? It means prosecuting, fining, and sending to prison all persons who associate themselves together for the lawful and innocent purpose of mutual support in sickness and adversity without registration; and that, obviously, cannot reasonably be done unless abstinence from registration is shown to be a moral offence; that is to say, unless the conditions of registration are such that a registered society shall be necessarily a good one, and an unregistered society necessarily a bad one. We must begin, at any rate, by devising model tables and insisting that every society shall adopt them. Are they not ready to hand? Did not my lamented colleague, Mr. Sutton, prepare a Blue Book of 1,350 pages full of them? That is true; but it is also true that in the brief introductory remarks which he addressed to me at the beginning of that report he observed, with great force, that the adoption of sufficient rates of contribution is not enough to secure the soundness of a society. Those rates are derived from the average experience of all classes of societies—some exercising careful supervision over claims for sick pay, others lax in their management—and it is upon care in the management, rather than upon sufficiency of rates, that the success of a Friendly Society mainly depends. If the members administer the affairs of their society with the same rigorous parsimony and watch over the claims for sick-pay with the same vigilance which a poor and prudent man is compelled to exercise in the administration of his own household affairs, the society will be more than solvent, even though they do not pay as high a contribution as the model tables exact. If they neglect these precautions, there is no model table which will rescue them from ultimate insolvency. In Mr. Sutton's happy phrase, it is the personal equation of the members and of their medical adviser that tells the most on the prosperity or the failure of a society. Your compulsory registration will impose unfair conditions on the well-managed societies, and will do nothing to prevent the inevitable collapse of those which are badly managed. Registration tells for a great deal while it is voluntary and free; but if you make it compulsory, and add to it conditions that you suppose will tend to soundness, you will inevitably do more harm than good. It is, of course, of vital importance that adequate rates of contribution should be charged for the benefits proposed to be insured; but if these are imposed by authority, the management of the societies must also be undertaken by the same authority. It is a curious observation, which has been borne out by experience, that in poor societies the claims for sickness are relatively less than in rich ones. M. Bertillon, the eminent French statistician, has shrewdly remarked: 'The truth is, that friendly societies, when they grant sick-pay, attach less weight to the text of their rules than to the state of their funds. If the society is rich, it grants relief more freely than if it is poor. Thence, and thence only, it comes that the great English societies, which are often very old and generally rich, give more days' pay than the French societies, for example, which are bound to a rigorous economy.' Without necessarily assenting to all that M. Bertillon says, it is easy to see that if the State were unwise enough to say that such-and-such rates would be sufficient, it would encourage laxity of management, and accept a responsibility that does not belong to it.

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I may now proceed to show that the present voluntary system, unscientific as t may be supposed to be, works very well on the whole. Its most useful feature s the valuation, for a society which disregards the lessons of one valuation finds tself pulled up sharply by the results of a second. A deficiency that is frankly aced by an increase of contributions, a reduction of benefits, or a levy, or by all hree together, will probably not only disappear, but be succeeded by a surplus; ut a deficiency that is disregarded not only grows at compound interest, but ncreases by the continued operation of the causes which produced it. It is to be emembered that a valuation deficiency or surplus, as the case may be, in a Friendly Society is always hypothetical. It means this in the case of deficiency—f you go on as you are going and do not modify your contracts, you will ultimately be in a deficiency of which this is the present value. In the case of surplus it means—if you go on as you are going and do not allow your prosperity to tempt you to recklessness, you will probably have enough to meet all your engagements, nd this much over together with its improvements at interest.

When Friendly Societies are considered in their economic aspect, they appear to be an excellent application of the principle of insurance to the wants of the industrial community. Sickness may come upon a working man at any time, and may disable him from work for an indefinite period. In such an event, if he had nothing to rely upon but his own savings accumulated while he was at work, they would before long be exhausted, and he would be left in distress. By combining with a number of others who are exposed to the same risk, he can fall back upon the contributions to the common fund which have been made by those who have escaped sickness. It is an essential part of every contract of insurance that the contributions of all who are exposed to an equal contingent risk are equal; but the benefits are only derivable by those of the number in whose experience the contingent risk becomes actual, and they receive more than they have paid, the deficiency being made up out of the contributions of those who have escaped the contingent risk.

This really seems too elementary a proposition to be worth stating, but it is the fact that the principle of insurance is so little understood that many members of Friendly Societies look upon themselves as having performed an altruistic and charitable act in joining a society when they have been fortunate enough not to make claims upon it through sickness. Several intelligent witnesses before Lord Rothschild's Committee on Old-age Pensions, representing large and well-managed societies, actually urged upon the Committee that the members of Friendly Societies were more deserving of old-age pensions than other people because they subscribed for the benefit of others and not of themselves.

Another economic point of view in which Friendly Societies call for consideration is that of their relation to the Poor Law. The old Act of 1793, which was the day of elaborate preambles to statutes, affirmed that the protection and encouragement of such societies would be likely to be attended with very beneficial effects by promoting the happiness of individuals, and at the same time diminishing the public burdens. The public burden at which this was pointed was no doubt the Poor Law, which was then administered in a very different manner from that which has prevailed since the great reform of 1834, and one of the items of encouragement which the Legislature provided for the societies was that their members should not be liable to removal under the Poor Law until they had actually become chargeable to their respective parishes. This exemption was no doubt of great value at that time, when the law of settlement bore very severely upon the poor.

It appears to me that the proper relation of the Friendly Societies to the Poor Law is a negative one. The main object of the societies should be, as indeed it is, to keep their members independent of the Poor Law. They have done so with great success. The returns which have more than once been presented to Parliament of persons receiving relief who are or have been members of Friendly Societies have frequently been shown to be untrustworthy. The number of actual members of such societies who seek relief is small absolutely, and still smaller relatively to the population. It was therefore not without regret that I observed

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the passing of an Act in 1894 which empowered Boards of Guardians to grant relief out of the poor rates to members of Friendly Societies, and if they thought fit to exclude from consideration of the amount of relief to be granted the amount received by the applicant from his Friendly Society. That Act has just been followed in the natural course of events by a bill for taking away from the Guardians their discretion in the matter, and requiring them to grant full relief to the applicant in addition to the weekly sum, not exceeding five shillings, which he receives from his Friendly Society. In other words, they are to provide a pauper who is a member of a Friendly Society with a free income of five shillings a week more than they would grant as adequate relief to a pauper who was not a member of a Friendly Society, however deserving in other respects that pauper might be. Poor-law relief, instead of being a painful and deplorable necessity, is elevated into a reward of merit in the one case, in which that merit has been displayed by joining a society. A kind of old-age pension is provided for the member, but instead of being an old-age pension without the taint of pauperism, it is a condition of obtaining it that the man must become a pauper. This seems to me to be topsy-turvy legislation. The very bodies whose aim and proud boast it should be that their members never are paupers have been contented to claim for their members the rank of privileged paupers.

The discussion of the subject of old-age pensions which has now been proceeding for the last twelve or thirteen years has had one good effect in bringing under the consideration of the Friendly Societies the practical methods by which they can obtain these pensions for themselves. The impression that some day and somehow the State would provide pensions for everybody, or at least for everybody who is thrifty, has had a bad effect; but the wiser members of the societies have seen that it would be a good thing to substitute for their present plan of continuing sick-pay to the end of life a plan of insuring a certain annuity after a given age. For this purpose they have had to overcome a natural reluctance on the part of the members to lock up their savings in the purchase of deferred annuities, and they have done so with some success, several thousands of persons having agreed to subscribe for these benefits. It is anticipated that the report of Mr. Alfred Watson on his investigations into the sickness experience of the Manchester Unity of Oddfellows will add force to this movement by showing how great a burden old-age sickness at present is, and how slight an additional sacrifice would secure a deferred annuity. It need hardly be said that it is more desirable that the members generally should do this for themselves than that they should get the State to do it for them.

Registered Friendly Societies are becoming more popular and more wealthy under the present system. The number of returns from societies and branches increased from 23,998 on December 31, 1891, to 26,431 on December 31, 1899, and 27,005 on December 31, 1901; the number of members from 4,203,601 to 5,217,261 in eight years, and to 5,479,882 in ten years; the amount of funds from 22,695,039*l.*, or 5*l.* 8*s.* per member, to 32,751,869*l.*, or 6*l.* 5*s.* 6*d.* per member, after eight years, and 35,572,740*l.*, or 6*l.* 9*s.* 9*d.* per member, after ten years. It is necessary to observe, however, that some of the numerical increase is due to greater completeness in the later returns. The increase in ratio is not affected by this. It may be worth noting that, on the average, the proportion of members under fifty years of age to those above that age is as 81 to 19; and that of the total aggregate receipts per annum, 73 per cent. goes in benefits, 11 per cent. in management, and 16 per cent. is added to capital. The average annual contribution per member is 1*l.* 1*s.* 6*d.*

Up to this point I have referred merely to the Friendly Society of the ordinary type, the sick club and burial fund. Societies of the collecting group, while registered under the Friendly Societies Act, are also regulated by a separate Act, and it is convenient therefore to consider them apart. They insure burial money only. They are only 46 in number, having increased from 43 in 1891. They have as many as 6,678,005 members, an increase from 5,922,615 in 1899 and 3,875,215 in 1891; but among these each individual above the age of one year in every family is counted separately, and the majority, therefore, are young children.

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Their funds are 5,973,104*l.*, or 17*s.* 11*d.* per member, having increased from 5,207,686*l.*, or 17*s.* 7*d.* per member, since 1899, and from 2,713,214*l.*, or 14*s.* per member, since 1891. These societies therefore show progress like the others.

The collecting societies do a similar business to that of the Industrial Assurance Companies, of which the Prudential is the type. Their ostensible reason for existence is to answer that instinct of human nature which makes even the poorest desire that the burial of the dead should be attended with some degree of ceremony; but strong as that instinct may be, it does not prompt the poor to seek out the office of the society and pay their premiums there. They have to be solicited by canvassers and waited upon by an army of collectors at their own homes; and the maintenance of this army and the general cost of management absorb nearly half the contributions, so that the poor insurer pays double the net price for his insurance. There is reason to believe, moreover, that these societies are largely used for speculative insurances by persons who have no real insurable interest in the lives insured. So long ago as 1774 an Act was passed for the purpose of checking this sort of gambling in human life; but as it only makes the policy void, the insurer takes the risk of the society repudiating the contract, knowing that its doing so would discredit it and spoil its business.

A number of other classes of societies are capable of being registered under the Friendly Societies Act, such as cattle insurance societies, benevolent societies, working men's clubs, and societies for any purpose the registry of which the Treasury may specially authorise. The formation of cattle insurance societies on a large scale was contemplated by an Act of 1866, when the cattle plague was at its height; but in practice only small pig clubs and similar societies in Lincolnshire and the neighbouring counties have been registered under this head. Benevolent societies are defined as societies for any benevolent or charitable purpose, and might therefore comprise all the charitable institutions of the United Kingdom, but in fact the registered benevolent societies are few. Working men's clubs—frequently called working men's clubs and institutes—were first brought under the operation of the Friendly Societies Act of that day by Sir George Grey as Secretary of State in 1864, and were then societies for purposes of social intercourse, mutual helpfulness, mental and moral improvement, and rational recreation. They are still so defined by law; what they are in fact has been revealed by the provisions of the Licensing Act, 1902, as to the registration of clubs. Rules have been submitted to the Registry Office, and we have been advised that we have no discretion to refuse to register them as rules for carrying out the excellent purposes just defined, providing for the supply of intoxicating liquors to members and their friends at hours when the ordinary licensed houses are compulsorily closed, for keeping the club open every night till midnight, and on nights when there are balls till six o'clock in the morning, and for other incitements to intemperance. I hope that it will not be long before an enactment is passed that the registry of a club under the Licensing Act shall vacate its registry under the Friendly Societies Act. Such clubs have nothing to do with thrift or with insurance; they are rather instruments of extravagance, improvidence, and dissipation.

Some of the specially authorised purposes are also wide of the mark, which upon the *ejusdem generis* rule should, I think, be pointed with strictness in the direction of provident insurance; but there has always been a desire liberally to extend the benefits of the Friendly Societies Act with a view to the encouragement of societies having praiseworthy objects which for want of means or some other reason are not registered as companies. The large majority of specially authorised societies are Loan Societies, and though these may in some cases be fairly good investments for those who lend, they are of doubtful benefit to those who borrow. An exception must be made to this statement with respect to the Agricultural Credit Societies, many of which have been established in Ireland by the exertions of Sir Horace Plunkett, and have been pecuniarily assisted by the Congested Districts Board. It is a feature of these societies that they not only lend money to the small farmer, but see that he spends it on improvements to his farm; and also that there is no division of profit among the members.

The returns from all societies under the Friendly Societies Act other than

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Friendly Societies proper increased from 557 in 1891 to 1,308 in 1899, and 1,4[illegible] in 1901; the number of members from 241,446 in 1891 to 610,254 in 1899, and 649,491 in 1901; and the amount of funds from 594,808*l.* in 1891 to 1,528,06[illegible] in 1899, and 1,686,656*l.* in 1901. Here, again, great allowance has to be made for the want of completeness in the returns of the earliest date.

Allied to Friendly Societies, but having special regulations under other Acts, are shop clubs and workmen's compensation schemes. In a vast number of large industrial establishments the men have their own sick club, sometimes assisted by the employer; and in a few the employer makes it a condition of employment that every workman shall join the club. Where this is done it is now enacted, not only that the club shall comply with the requirements of the Friendly Societies Acts as to registry, but also with other conditions of more stringency. As yet only a few clubs have been able to satisfy all the requirements of the Shop Clubs Act, 1902. The workmen's compensation schemes provide an alternative to the general scheme of compensation to injured workmen contained in the Act of 1897, and have enabled the employers and workmen in several large industries to enter into mutual arrangements by which the workman gains an equivalent to the compensation which the Act would give him, and enters into partnership with the employer for obtaining other benefits. According to the returns, these schemes have hitherto resulted very favourably to the workmen, and it seems a pity there are not more of them.

The sentiment of which I have spoken, that it is desirable to extend the benefits of the Friendly Societies Acts to societies for good objects, even though these objects may not be purposes of provident insurance, is expressed in the statute of 1834, which allowed of 'any purpose which is not illegal,' and in that of 1846, in which the definition of a Friendly Society was made to include the frugal investment of the savings of the members for better enabling them to purchase food, firing, clothes, or other necessaries, or the tools, implements, or materials of their trade or calling, or to provide for the education of their children or kindred. Under these Acts the Rochdale Equitable Pioneers and a number of other Co-operative Societies were registered, and in 1852 an Act was passed specially dealing with these bodies under the name of Industrial and Provident Societies. They were made corporate bodies by an Act of 1862, and are now regulated by the Industrial and Provident Societies Act, 1893. The societies that may be registered under this Act are societies for carrying on any industries, businesses, or trades specified in or authorised by their rules, whether wholesale or retail, and including dealings of any description with land.

This definition indicates pretty clearly the manner in which Co-operative Societies have worked out their own evolution. The expression 'Industries' denotes the productive form of society, a form which has always embodied the ideal of co-operation when the combined labour of the members should be engaged in the production of commodities. The expression 'Businesses' indicates the recognition of the Legislature that Co-operative Societies ought to cover a wider range than was allowed by the words 'labour, trade, or handicraft' in the Act of 1876, and include banking, assurance, and the like. The expression 'Trades' denotes the distributive form of society, a form in which co-operation has gained its greatest success. The permission to carry on these functions 'wholesale' as well as retail points to the system of super-association, or co-operation between societies, which has attained phenomenal proportions in the co-operative wholesale societies of Manchester and of Glasgow, and exists in a smaller degree of development in other societies. The authorising of 'dealings of any description with land' relates not merely to a considerable number of land societies, but is also an indication of the great extent to which societies for other purposes have applied their profits and some of their capital to the excellent work of providing homes for their members. It is also to be observed that many societies are both distributive and productive.

What have these societies done for their members? They have reduced the price of the necessaries of life and have thus enabled persons of limited means to enjoy some of its luxuries; they have provided a remunerative investment for

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small savings; they have done much to put an end to the practice of giving and taking long credit; they have done as much as in them lies to ensure the purity of commodities; they have discountenanced (though, perhaps, not with all the success that might have been hoped for) the practice of taking commissions and commercial bribery generally; they have raised the standard of comfort and have helped many members to obtain the coveted possession of a house of their own; they have devoted a share of their profits to educational purposes with excellent results. Some of the productive societies, by the practice of giving a bonus to labour, have improved the economic position of the workman and contributed to the efficiency of his work. On the other hand, co-operative societies generally have not been so successful as was expected in realising some of the aspirations of the founders of co-operation; commercial failure has not been unknown among them; losses have occurred, though the simple organisation of the societies has made it easy to deal with them by adjustments of the capital account; they have not always had the best of managers, and have sometimes failed to give their confidence where it was deserved, and given it where it was not. In many places they have had to contend with opposition from the traders to whose business and profits their success was unfavourable. Taking all things into consideration, the progress they have made is surprising.

Comparing the returns for the United Kingdom for the years ending December 31, 1891, and December 31, 1901, the increase in number of societies was from 1,597 to 2,175; in number of members from 1,136,907 to 1,929,628; in amount of funds from 16,545,138*l.* to 40,824,660*l.*

It has been observed that the Co-operative Societies are largely undertaking the work of providing houses for their members; and to that it may be added that the Friendly Societies are more and more tending to adopt the practice of lending money to members on mortgage as one of the most remunerative forms of investment open to them. The Building Societies, which were established for that purpose only, are still carrying on the same work, and the combined operation of all three ought to produce a material effect on the prosperity and well-being of the industrial population. Building Societies alone advance as much as 9,000,000*l.* a year on mortgage.

Building Societies have passed through a crisis. The incorporated societies reached their highest point of prosperity in 1887, when their capital amounted to fifty-four millions; by 1894 it had fallen to below forty-three millions. The Building Societies Act, 1894, required of societies a fuller disclosure of the real state of their affairs than had previously been called for. The result was to show that, apart from the special scandal caused by the fraudulent proceedings of the Liberator Society, there were hitherto undisclosed elements of weakness in the management of Building Societies that justified the withdrawal of the public confidence that had been reposed in them. The properties in possession before the passing of the Act of 1894 were not less than 7,500,000*l.*; they are now less than 3,000,000*l.* This points to the fact that the early prosperity of Building Societies had led to the establishment of more societies than the public demand called for, with the consequences that societies competed against each other, and that in the stress of competition and the anxiety to do business they accepted unsatisfactory securities, which must lead to loss upon realisation. From this point of view the effect of the Act of 1894 has been wholly salutary. Year after year the societies have reduced their properties in possession. The evils which they dreaded from the disclosure of the facts have not arisen. At this day it may be said that the societies as a whole have regained the position they held in public confidence, for the members now know the worst. They know, too, that where the blight of properties in possession still infests the business the managers are resolutely endeavouring to diminish its effect.

I need hardly repeat what has so often been said of the economic value of a sound Building Society. The man who by its means gets a stake in the country mounts many steps on the social ladder. When he has paid off the mortgage on his own dwelling-house, and so liberated himself from the obligation to pay principal and interest, either in the form of repayment annuity or of rent, what

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is to prevent him from buying in the same manner, as an investment, another house with the income thus set free, and so on?

There are still sixty-eight Building Societies which remain under the operation of the Act of 1836, having been established before 1856, and not having availed themselves of the option of taking upon themselves the responsibilities and the privileges of the Acts of 1874 and subsequent years. One society (the Birkbeck) stands by itself, as, although its business as a Building Society is considerable—the new advances granted on mortgage last year having been for 120,000*l.*—its main operations are those of a deposit bank, and it keeps the far greater part of its funds in investments on liquid securities. The other societies are pursuing the even tenor of their way, just as they have done for the last fifty years, and show on the average an increase of business from year to year. But the great body of Building Societies are those which are incorporated under the Acts of 1874 to 1894, exceeding 2,000 in number. They have so far recovered from the effects of the depression that their assets are now forty-eight millions, being midway between the low-water mark of 1894 and the high-water mark of 1887. That and the fact that they have in about seven years reduced their properties in possession by about 60 per cent. leads to the inference that they are now, speaking generally, in a fairly healthy condition, and that many years of usefulness are still to be expected for them.

The Friendly Societies Registry also registers and receives returns from trade unions. These useful and necessary bodies have, I think, been rather cruelly treated, not only in past days, but also in more recent times. Without going back to the bad old times when six poor agricultural labourers were sentenced to seven years' transportation for forming a trade union, or even to the time when they were refused the protection of the law for the funds they had accumulated because, forsooth, they were for an illegal purpose, it will be sufficient to mark the unexpected change that has been worked in their position since the Act of 1871 purported to render them legal. Registry under that Act authorised the trustees of a trade union to hold land not exceeding one acre, vested the property of the union in them, authorised them to sue and be sued on behalf of the union, limited their liability, made the treasurers and officers accountable to them or to the members, and enabled them to take summary proceedings against any person misapplying their funds. But it did not create the unions corporate bodies, and did not enable any Court to entertain legal proceedings for enforcing their contracts with their members, recovering contributions due from a member, or recovering from the union benefits due to a member or other person, or for enforcing any agreement between one trade union and another, even where any such contract or agreements were secured by bond. It was commonly thought that the effect of all this would be that the unions, having none of the privileges of incorporation, would escape the liabilities which affect corporate bodies; and so much was this the general opinion that the Duke of Devonshire and other members of the Royal Commission on Labour made a minority report in which they suggested that the law in this respect should be altered.

It has recently been determined that, although unions are not corporate bodies they are responsible for the acts of their agents as much as if they were. I do not presume to question the propriety of this decision as a matter of law, nor even to say that it is a decision which is contrary to equity; but only to point out that its result upon the individual member of a trade union, who gave no mandate to its agents to do any illegal or injurious act, but handed over his savings to the trustees of the union, relying on the stringency of the provisions of the Act as to misapplication of funds, is very serious and was unexpected. The contributions of workmen to their trade union represent an amount of self-sacrifice and self-denial that is not readily gauged or measured or understood by persons in easier circumstances of life. Their object, which is primarily to provide the sinews of war in any conflict that may be necessary to secure their material welfare, and secondarily to provide sick and funeral and pension and out-of-work benefits against the ordinary ills of life, is one that ought to appeal most strongly to the sympathies of the economist. If it is the fact that trade unions make mistakes, as most people

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do, those mistakes will be much fewer and less mischievous when full legislative recognition and protection are afforded them than they were under the old *régime* of suspicion and repression.

Loan Societies under the Act of 1840 are societies for lending sums of money not exceeding 15*l.* to the industrious classes upon terms of a deduction of interest at the time of granting the loan and a corresponding weekly repayment fixed to commence at such a time that the rate of interest earned by the society shall be about 12 per cent. per annum; another instance of the experience which always faces the poor man that he has to pay for any small accommodation he wants a higher relative price than the man has who wants more. These societies are of two types: the Friends of Labour Loan Societies, existing mainly in the metropolis, having two classes of members, investing and borrowing, but limiting the subscriptions of the one class to the 15*l.* which is the statutory limit of the loans to the other class; and what may be called the proprietary loan societies, existing mainly in Yorkshire, making their loans to non-members, and consisting of a small number of persons who contribute the whole of the capital, the holding of each proprietor sometimes amounting to several hundreds of pounds.

The Registry of Friendly Societies has for one of its functions that of granting to societies which are exclusively for purposes of science, literature, and the fine arts certificates exempting them from local rating. Though there can be no question that these certificates are of great value to many excellent institutions, such as public libraries, picture galleries, museums, and scientific and learned societies, which would find the liability to pay rates, in these days when rates have increased and are increasing so largely, a serious deduction from the scanty means at their command for maintaining their useful operations, yet I have very grave doubts whether on economic grounds any such exemption from rates is capable of being defended. The benevolent people who subscribe to maintain these buildings for the public good increase the burden upon the small ratepayer to the extent to which they fail to contribute their share. The Act of 1843 has more than once been scheduled in Bills for repealing exemptions from rating, but those Bills have not been passed, and the Act is still in force.

There only remains to consider the case of Savings Banks, which are brought in connection with the Registry of Friendly Societies by the Acts which confer upon that office exclusive and final jurisdiction in the settlement of disputes, and effectually oust the jurisdiction of the Courts of Law. Under these Acts many thousands of disputes have been settled by my predecessors, my colleagues, and myself, and at the present time an average of three appointments every week during the busy time of the year has to be made to hear the parties. We see much of the seamy side of life in these cases—many family and other quarrels of a sordid character are brought to light—and it has been noted as a curious fact that persons guilty of fraud or embezzlement seem frequently, but most unwisely, to select the Savings Bank as the securest receptacle for their ill-gotten gains. On the other hand many pathetic and touching instances of thrift and self-sacrifice have been brought under our notice, and much evidence has been accumulated as to the great value to the poor of these excellent institutions. As compared with the several self-governing bodies to which I have already called attention, the Savings Bank may not unfairly be described as the elementary form of organisation for thrift. The depositor entrusts his money to it for mere safe custody and accumulation, and has no voice in the application of it or control over its managers. All he asks is that he may run no risk of losing it. Savings Banks are of three classes: the 230 Trustee Savings Banks of the old type which still remain, and have to their credit an undiminished amount of funds, though there were at one time more than twice as many banks; the Post Office Savings Bank, which is one of the many monuments still extant to the financial genius of Mr. Gladstone, and not less to the administrative skill of the public servants who settled the lines upon which it works, and which has increased the savings of the people more than threefold by bringing almost to every man's door the opportunity of making deposits. I hope that it may meet in its new and splendid home at West Kensington with a continuance and increase of the marvellous success which has hitherto attended it.

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Thirdly, there are the Railway Savings Banks, which have collected from the workmen employed and from their families nearly five million pounds. It is right to observe that they give a rate of interest exceeding by about 1 per cent. that given by the Trustee and Post Office Savings Banks. It is also to be borne in mind that the deposits in Savings Banks are not drawn wholly from the industrial population, but that many, especially women and children, belonging to other classes make use of the banks. Indeed, the Postmaster-General, in an approximate estimate made some years ago, calculated that women and children constituted 56 per cent. of the whole number of depositors. School Savings Banks and Penny Savings Banks are also to be mentioned as feeders of the ordinary Savings Banks, and as greatly increasing the opportunities of saving afforded to the young, and instilling into them valuable lessons of thrift.

Such is the story the department I am about to leave has to tell of the free and spontaneous efforts of the industrial population to better their condition by means of thrift and economy. It is, I venture to think, one which speaks well for the general body of that population and has great promise for the future of the country. In times of depression, as well as in times of prosperity, the gradual increase of the funds of these various bodies has been maintained; the members have not been compelled by the one, nor tempted by the other, to relax their efforts and their sacrifices.

I ask forgiveness for having detained you so long on so small a branch of the great subjects with which this Section has to deal, and which will be well illustrated in the important papers and discussions that are set down on its programme. The course of events has given to one group of subjects, that has often been considered in this Section, a new and unexpected prominence; and we await with keen interest the teaching which economic science has to offer on the questions of the day.

The following Papers were read:—

1. *The Growth of Rates.* *By* BENEDICT W. GINSBURG, *M.A., LL.D.*

Without attempting to deal with this question as a whole, the paper is designed to show the impossibility of raising, as is proposed, large sums of money from our provincial cities for the purposes of higher education. With this view the statistics of seven important towns—Birmingham, Bradford, Bristol, Leeds, Liverpool, Manchester, and Sheffield—are examined, and the area, population, rateable value, amount raised by the rates, and levy of rates per pound over decennial periods for the last half-century, taken out. Liverpool, as being the nearest and perhaps the most important city, is taken as an example, and her position discussed in detail. Comparing 1881 with 1851 it appears that though the population and rateable value had increased, the rates had also risen from 1*s.* 8½*d.* to 3*s.* 11¼*d.*, so that the amount extracted from the ratepayers rose from 134,000*l.* to 609,000*l.* per annum. In 1901 it had further risen to 6*s.* 9¼*d.* in the pound, the increase over the amount of ten years previously having been 84 per cent. The movement of municipal indebtedness, not only for remunerative undertakings, but also for general purposes over the whole country, has also been upwards. The Local Government returns show a total expenditure for all the municipalities of 88 millions in 1898, and of 121 millions in 1902, on reproductive works. The return which is made, however, by these undertakings is not proportionate to the capital charges incurred. Liverpool, for example, has spent 7¾ millions to obtain a return of but 45,000*l.* per annum. The ancient sources of expenditure, such as the poor law, are not those upon which the present large outlays go. Housing, electricity, tramways, and education account for most of the increase. In the last ten years Manchester's contribution to the School Board has trebled, rising from 40,000*l.* to 120,000*l.*, Birmingham's has risen from 73,000*l.* to 134,000*l.*, and Liverpool's from 62,000*l.* to 128,000*l.* In view of these facts and of the probable results of the new Education Act, it would seem improper that new undertakings should be even contemplated.

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2. *Depreciation and Sinking Funds in Municipal Undertakings.*
By STANLEY HORSFALL TURNER, *M.A.*

The questions to be raised centre about the fact that all municipal undertakings are started with borrowed capital which must be repaid within statutory periods, and it is important to understand how this initial burden should be distributed as between the present and the future. Usually in reproductive undertakings the sinking fund is based upon the life of the subject, and beyond this there is, in general, no obligation to provide reserves. No decisive answer has at any time been given to the question whether depreciation funds should be kept, with the result that municipalities differ very widely in their methods. A few have adequate depreciation funds, others have either inadequate ones or none at all. According to the latest returns the annual average depreciation fund for municipal tramways in England and Wales is only just over one half per cent. on the capital borrowed, and tramways show the largest percentage of any municipal industry. It is urged by those municipalities which have no depreciation fund that the sinking fund, being based upon the life of the subject, *is* the depreciation fund, and that if the loan is entirely repaid when the plant is worn out or obsolete the present has done all that is necessary. Their successors must borrow to reinstate the works. The only alternative, as the law now stands, is to have a depreciation fund in addition; and if this were a true depreciation fund it would be too great a burden upon the first generation, since the life of the subject is taken into account twice over. Those municipalities which voluntarily lay aside a full depreciation fund urge that once an undertaking is started its value should be maintained, as in a private company working a similar undertaking, and that the sinking fund is an *extra* requirement enforced by Parliament because it is deemed undesirable to allow any permanent local debt. While this second view recommends itself as the sounder finance for reproductive undertakings, there are serious objections to it so long as the sinking fund is fixed on the present principles. The first generation is burdened twice as much as the second and succeeding generations. It not only repays the whole debt, but also builds up an equal capital for future generations which have no sinking fund to pay because their capital is no longer borrowed. The difficulty arises because the statutory requirements, which contemplated none of the recent extensions of municipal activity, are not suited to some of the present undertakings, and in these cases a depreciation fund should be made obligatory, while the sinking fund should be entirely dissociated from the life of the subject.

FRIDAY, SEPTEMBER 11.

The following Papers and Report were read:—

1. *The Wealth of the Empire, and how it should be used.*[1]
By Sir ROBERT GIFFEN, *K.C.B.*

The paper is intended to initiate a discussion on the objects of the expenditure of the aggregate wealth of the British Empire, whether by individuals or by the State.

For the purpose of the discussion it is assumed, on the basis of recent investigations, that the aggregate income of the people of the United Kingdom may be placed at about 1,750 millions, and the aggregate wealth at about 15,000 millions. The data as to the rest of the empire are not so familiar, but the aggregate income of the whole empire is put at 3,130 millions, including 270 millions for Canada, 210 millions for Australasia, and 600 millions for India. The corresponding capital for the whole empire is assumed at 22,250 millions, including

[1] Published in the *Journal of the Royal Statistical Society*, October 1903.

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1,350 millions for Canada, 1,100 millions for Australasia, and 3,000 millions for India.

Attention is next called to the report of a Committee of the British Association, consisting of Professor Jevons, Mr. Leone Levi, Mr. Stephen Bourne, and others, who investigated in 1881 and 1882 the subject of the actual expenditure by the people of the United Kingdom, and reported to the meetings of the Association at Southampton in 1881 and Southport in 1882. In their first report, dealing with a total of 878 millions of expenditure, the Committee expressed the opinion that 500,400,000*l.*, or 56·9 per cent., were spent on food and drink; 147,800,000*l.* or 16·8 per cent., on dress; 121,700,000*l.* on 'house,' including house-rent, furniture, coal, gas, and water; while among other items there were 1·5 per cent. spent on tobacco, 1·3 per cent. on education (less than on tobacco), 1·4 per cent. on 'Church' (also less than on tobacco), 0·8 per cent. on 'literature,' 0·6 per cent. on newspapers, and 0·7 per cent. each on 'theatres and music-halls' and 'other amusements.' It is pointed out that such a distribution of expenditure is not surprising to those acquainted with family budgets. The bulk of what people spend naturally goes primarily to food, clothing, shelter, and defence; and the miscellaneous and what may be called the higher ends of civilised existence have less proportionate amounts devoted to them.

Applying with some variation the principles and methods followed twenty years ago, we obtain the following analysis of a sum of 1,386 millions expended at the present time:—

	Million £	Per cent. of total
1. Food and drink	468	34
2. Dress	182	13
3. House	223	16
4. National services (exclusive of education)	183	13
5. Miscellaneous (including education) . .	130	9
6. Cost of distribution	200	15
Total	1,386	100

According to this the proportion of the food-and-drink bill is apparently less than in the report of the Committee of 1881; but this is largely due to a difference in the mode of arranging the figures. If the last item of all, the cost of distribution, were spread proportionally over the earlier items, and the taxes on tea, sugar, beer, and other articles were also included with them, the food-and-drink bill would be more nearly 600 than between 400 and 500 millions. Another cause of the change is the fall of prices since 1881. Generally the order of the items of expenditure is much the same as twenty years ago. A similar table for the whole empire would show some variation, as a poor community like India spends more in proportion for food, while the self-governing colonies are exempt, or exempt themselves, from defence items, which constitute a large part of the expenditure for national services in the United Kingdom.

Discussing the question of what expenditure should be, the *first* point we raise relates to the food-and-drink bill. It is suggested that there is probably economic waste in some directions, especially in the expenditure by the artisan and wealthier classes on meat and alcohol; but equally there are large numbers of the people insufficiently fed, though we may not accept fully the recent inferences commonly made from the writings of Mr. Rowntree and Mr. Charles Booth. Attention is drawn to the economic gulf separating the United Kingdom and the self-governing colonies from India and like parts of the empire occupied by subject races. We find that forty-two millions of people in the United Kingdom consume in food and drink alone, if we take the expenditure at the retail point, an amount equal to the whole income of three hundred millions of people in India.

A *second* point raised relates to the expenditure on housing. Great as the increase of this item has been since the report of twenty years ago—the expendi-

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ture being about double what it was, with an increase of less than one-fourth in the population—we must look for further outlay in this direction as the wealth of the population increases. The increase of expenditure, it is to be feared, has not been accompanied by an equal increase of accommodation, being due in part to a rise in the monopoly value of town and suburban areas and an increase in the cost of building.

A *third* point raised is the adequacy of the amount spent on army and navy services, included under the heading of 'national services.' While the sum spent for civil government (excluding education), though large—about 114 millions—is allowed to be in all probability legitimate for the most part, being for such purposes as post-office, law and order, sanitation, and the like, and a sign rather of the advanced condition of the people, it is suggested (1) that the sum of seventy millions for army and navy may be insufficient, and (2) that the amount of the proper expenditure for these purposes is not really a matter for choice, but one that must be decided absolutely by expert opinion. The burden of seventy millions is about 4 per cent. only of the aggregate income of the people of the United Kingdom, and 0·47 per cent. of their wealth. When the empire is surveyed as a whole it is feared that the only sensible addition made to the above outlay for defence is by India, which spends eighteen millions out of its poverty, the remainder of the empire not spending five millions altogether. How to organise properly the defence of the empire as a whole is a question that does not seem to have been taken rightly in hand by our authorities, who insist too much on money contributions from the different parts of the empire to a distant centre, instead of addressing themselves to the development of local resources.

The *last* point raised is as to the sufficiency of the expenditure on education—about thirty millions only in the United Kingdom, including imperceptible amounts for scientific investigation, while in the rest of the empire the amounts are also small, the Government expenditure in India, for instance, being about two millions only. The United Kingdom ought to be spending 100 millions where it now spends thirty. Such sums are not really extravagant. Extensive diffusion of education and scientific knowledge and training are not only essential to the greater efficiency of labour and capital by which the means of living are provided, but they are equally needed for the conduct of life itself, for the health and comfort of the workers, their freedom from debasing superstitions and prejudices, their capacity to enjoy the higher pleasures, and their ability to manage all common affairs. The funds to meet such increased expenditure will be provided easily enough by the greater energy and efficiency of labour which education will develop, and by the abandonment to some extent of the present national ideas respecting play. India and the like parts of the empire should also receive a corresponding development. Education is the watchword, and should be the first thought in our minds.

Finally a suggestion is made that the investigations of the Committee of 1881 as to the actual objects of expenditure should be resumed and continued.

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2. *Report of the Committee on the Economic Effect of Legislation regulating Women's Labour.*—See Reports, p. 315.

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3. *On the Rating of Land Values.* *By* J. D. CHORLTON.

The amount of local rates and also the rate in the pound have rapidly increased in recent years owing to the growth of population and the development of urban communities. At the same time, and for the same reasons, the value of land in towns and urban districts has very largely increased, and in some cases has been multiplied many times over. Hence the proposal to rate land values.

The minority of the recent Royal Commission on Local Taxation recommended the addition of a site-value rate to our present system of rating. The result will be the creation of a graduated system of rating, properties on more valuable sites

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paying a larger proportion of their value in rates than properties in less valuable sites. The incidence of the present rates paid in respect of inhabited houses is just as much upon occupier as if the same amount of money were raised by a local income tax. The incidence of a site-value rate will be upon the owners of site value. The best method of collecting the rate will be to levy it upon the occupier, with permission to him to deduct it or part of it from his rent.

Present contracts ought not to be excepted, but the holders of chief rent or perpetual annuities charged on land ought not to be rated.

The rate will tend to fall in its capitulated value upon those persons who own the land at the date of the imposition of the rate. The rate should therefore commence at a small figure.

A separate valuation of land and buildings is possible, and its cost would not be excessive. Uncovered land in the neighbourhood of large towns should not be taxed.

4. *The New Labour Party in its Economic Aspect.* *By* H. B. Lees Smith, *M.A.*

History of the new Labour party. It makes a compromise between the 'old' and the 'new' trade unionists. The two main points at issue:—

(1) The older school distrusted appeals to the State, but the younger advocated a somewhat dogmatic socialism.

(2) The older wished to act with the Liberal party, while the younger fought for an independent Labour party.

The new party was called into existence at the Plymouth Trade Union Congress in 1899. A resolution was carried that a conference be called 'to devise ways and means to secure the return of an increased number of Labour members to the next Parliament.' This led to the formation of the Labour Representation Committee. At first the older school held aloof. The alarm caused by the Taff Vale case, however, pushed the new party to the front. In February 1903 the members affiliated to the Labour Representation Committee numbered 861,150, an increase of 83 per cent. in a year.

The compromise may be expressed as follows:—

(1) The newer school do not insist on members being pledged to any socialist dogma.

(2) The old unionists have given way on the question of forming an independent party.

There seems to be little doubt that collectivism will be the foundation of the social policy advocated by the new party. By what kind of economic reasoning will this collectivism be supported? The danger of Marxist theories being popularised. Pamphlets and speeches by Labour leaders show that this is by no means slight. It is best seen by an outline of the Marxist system. This may be divided into two parts:—

(1) The labour value theory. Criticism.
(2) The theory of surplus value. Criticism.

Examples are adduced showing the influence of these doctrines on 'workshop economics.'

5. *A Contribution to the Statistics of Production and Consumption of the United Kingdom.* *By* S. Rosenbaum, *B.Sc.*

An examination of the figures relating to the production and importation and total consumption of corn during the years 1872–1901 shows the following facts: Wheat land in the United Kingdom has gone down from 3½ to below 2 million acres; barley land from 2,600,000 acres to 2,100,000 acres; and oats land from

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1,190,000 to 4,140,000 acres. The estimated yield of corn has in the same period gone down (by quinquennial averages) from 97 to 58 million bushels in the case of wheat; from 82 to 66 million bushels in the case of barley; and the yield of oats has risen from 147 to 151 million bushels.

The imports have in the same period gone up steadily and rapidly; while the amount remaining for home consumption per head of population has steadily diminished. The fall in the case of wheat amounts to an equivalent of 24 lb. bread per annum. In the above maize has not been included.

Somewhat similar results follow an examination of the meat-supplies of the country. The consumption of beef is estimated to have increased from 680,000 to 750,000 tons; of mutton there has been a decrease from 420,000 to 390,000 tons; while pig meats have remained stationary at about 290,000 tons. In addition to these, imported meats have increased enormously. The consumption per head of all kinds of meats has also greatly increased.

The yield of home-produced butter and cheese has not increased. Measured by the consumption per head, the butter (including margarine) consumed has increased from 11 lbs. to nearly 16 lbs. per annum, while the cheese has remained quite stationary at 13½ lb. per annum.

Further tables are given relating to coal. The first compares the growth of the production of the principal coal-countries with the total world's production. The second compares the production and consumption, total and per head of population, of coal from 1872 to 1901. The third gives an analysis of coal consumption for the principal British industries. Further tables relating to pig iron and wool are also given, and the whole is further illustrated by charts.

MONDAY, SEPTEMBER 14.

The following Papers were read:—

1. *The Potentialities of Applied Science in a Garden City.* *By* A. R. SENNETT, *A.M.Inst.C.E.*

The author drew attention to the economical and other advantages to be derived from careful coalition of the various branches of science involved in the building up of a modern city, in the case of such being reared upon *terra natura*, and entirely unhampered by considerations of prior design or demolition. He pointed out that the epoch at which we have now arrived in these islands, in regard to the existence and development of large towns, had led to the almost entire abandonment of hope that any scheme compassing the much needed 'return to the land' could ever now be consummated; and announced that, not only had such a scheme at length been evolved, but that, in a practicable and workable form, it is at once to be put to experimental test upon a scale amply sufficient to demonstrate its successful working, viz. in a community of from 25,000 to 30,000 inhabitants.

He attributed the inception and successful maturation of the scheme to Mr. Ebenezer Howard. The basis upon which it was founded was the assumption that, given the freehold acquisition of a site of sufficient extent and at moderate cost, vested in trustees in the interests of the future community, the financial success of the undertaking can be assured—no matter to what magnitude it may eventually be carried—by the reservation for the benefit of the community of the increment in terrestrial value of such site due to the emplacement thereon of a city laid out upon such lines that overcrowding is an impossibility, providing for the allotment *per capita* of such an extent of ground area as to entitle the creation to the cognomen of a 'Garden City.'

The coalition of public works, in the author's opinion, was prepollent to produce not only economic results, but an hygienic city free from smoke and fog,

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To the latter end he advocated the entire suppression of the consumption of solid fuel and the substitution of heating by means of a cheap non-illuminating gas, both for domestic fires and industrial processes, as well as gas produced by the Mond process for motive power.

To enable the municipality to supply heat, light, and motive power at the cheapest rate, the production of both gas and electricity should be vested in it, together with water-supply and the supply of electricity for public locomotion.

The necessity for the almost incessant breaking up of the streets, pavements, and roadways of large towns in connection with the various supplies and services has become a serious hindrance to traffic and commerce, and in this regard the author advocated the universal employment of subways beneath the side-walks, and illustrated one of his design, which, whilst making provision for the running of all the services, such as gas, water, electric light, telegraphs, telephones, &c., and their inspection, maintenance, and repair from below, also provided a means for the removal of sludge without the necessity for the employment of mud-carts.

In connection with this and the watering and scavengering of urban thoroughfares, the author advocated and explained a new form of road section—styled an 'invert road'—in which the 'crown' is discarded in favour of two slightly inclined planes sloping *from* the kerbs of the side-walks and meeting in a continuous grid at the centre of the roadway. Such a contour, he contended, possessed many advantages, among them that the use of watercarts would be rendered unnecessary by the employment in connection with them of hydraulic kerbs.

In connection with the sanitation of the city, the author emphasised the importance of devising a means of house-refuse removal, in which the bins should not be emptied into carts in the public highways, and explained his system, in which the lids are not lifted from the time the bins are collected from the houses until they are delivered at the destructor, the transportation being effected by means of a specially constructed cellular motor-waggon.

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2. *The First Garden City: its Economic Results.*

By HAROLD E. MOORE, *F.S.I.*

Many who consider favourably the proposals of Mr. Howard and other speakers on 'Garden Cities' are of opinion that the economic difficulties in their foundation are insurmountable. This question is now considered, as a site has been selected for the first of such cities.

The site chosen, which will be in the possession of the Garden City Company from Michaelmas, comprises about 4,000 acres coming to within one mile of the town of Hitchin and about thirty-six miles from London. The company will doubtless immediately erect a railway station in the centre of the estate, two and a half miles from Hitchin; make roads, giving access to that station; erect and fit a brickworks; open a chalk-pit; equip gravel-pits; and do other work which will render available the natural resources of the estate. The total cost will then probably be about 180,000*l.* This will be an average of about 30*l.* an acre for the agricultural land, excluding the buildings and accommodation land at a reasonable value. Two different courses of procedure will then be possible.

The first method is to lay out a model town with avenues and parks and spend large capital in engineering works and buildings. It is suggested that this procedure would result in failure. It would necessitate a large unproductive capital expenditure, cause annual expense in maintenance, involve serious financial risks, and reduce the present agricultural rental and value.

The second method would be to attract residents on small areas by offering sites with existing frontages at a rent charge, and also to encourage manufacturers to take land by giving them sites on that part of the estate suitable for manufacturing purposes on condition that they took further areas at a rent-charge for the erection of cottages for their workpeople. These cottages to be erected by the manufacturer, the intending occupier, or by builders who conform to the

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stipulated 'Garden City' regulations. It is suggested that this method will confer all the advantages claimed for 'Garden Cities' with satisfactory economic results. The rent-charge, even in respect of the most outlying land, would reasonably be not less than double the agricultural rental, while for building sites the rent-charge would be many times larger. The increased value secured by this greater rental without risk might then soon justify expenditure of capital on various town developments and improvements.

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3. *Physical Degeneration and the Poverty Line.* *By* Mrs. H. Bosanquet.

The interest which has been aroused in the physical condition of the people has given rise to alarming statements as to the extent and cause of physical degeneration. It is popularly assumed that one-third of the population is too poor to maintain itself in physical efficiency, and it is supposed that this assumption is justified by the investigations of Mr. Booth and Mr. Rowntree.

An examination of their work, however, shows that their results apply only to London and York, and that, *primâ facie*, there is a great discrepancy between their figures. This may be set out as follows:—

Mr. Booth: People with incomes at the rate of 21*s.* or less for a moderate family, 30 per cent. of the population.

Mr. Rowntree: People with incomes at the rate of 21*s.* 8*d.* or less for a moderate family, 9·91 of the population.

It appears, further, that Mr. Rowntree brings up his numbers classed below the poverty line to 27·84 per cent. by adding 17·93 per cent. who are living in apparent poverty, although their incomes are sufficient to raise them above it. It seems probable that Mr. Booth's 30 per cent. also includes a large majority whose condition is not due to want of money.

With reference to physical degeneration the evidence from recruiting statistics is hardly enough to prove degeneration from any standard previously attained considering the abnormal circumstances under which recruiting has recently been carried on, while much of the evidence before the Scottish Commission goes to show a decided improvement. Nevertheless many children never attain their proper development, and are greatly in want of better care and feeding. These are mainly the children living in secondary (*i.e.* apparent) poverty whose parents have the means to nurture them properly, but are too ignorant or too careless to do so. The evil, being not mainly due to poverty, cannot be met by subsidising the parents' earnings; nor would school feeding, whether free or paid for, be sufficient to meet all the needs of the children. They can only be met ultimately by educating women to a more adequate fulfilment of their duties as wives and mothers, and meanwhile by dealing with neglected children individually.

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4. *A Comparison of Exports to the United States, European Protective States, and our Colonies.* *By* B. Ellinger.

This paper is an endeavour to answer the following questions put by Mr. Chamberlain at a recent meeting of the Constitutional Club:—

Is it a fact that the exports of our manufactured goods to our Colonies already exceed the total exports of our manufactured goods to the protected States of Europe and the United States? In the second place is it a fact that our exports to those protected countries are continually and of recent years rapidly decreasing in quantity, deteriorating in their profitable character?

In order to make comparisons I have divided the last twenty years into periods of five years, and taken the average annual export over each such period.

I have excluded Turkey and Holland as not being protected States, and I have

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excluded Hong Kong and Singapore from our Colonies as being purely distributing centres. On the other hand I have included with our Colonies all British possessions except British India and Ceylon, figures for which are separately stated.

Our exports of manufactured goods to European protected States and the United States over 1898–1902 averaged annually 30,000,000*l.* more than our exports to our Colonies, being 84,000,000*l.* against 54,000,000*l.* It is necessary to add our exports to India and Ceylon, 32,000,000*l.*, to bring the total up to that of our exports to the United States and European protected States.

Our exports of manufactured goods to the United States have largely decreased in the last twenty years, from an average of 24,800,000*l.* in the years 1883–87 to an average of 17,700,000*l.* in the years 1898–1902, the whole decrease being nearly accounted for by decrease in woollen goods and metals.

Our exports of manufactured goods to European protected States show a substantial increase over the same period of 21½ per cent., while France shows a loss of 1,500,000*l.*, Germany shows an increase of 5,000,000*l.*, and our trade to Russia has doubled itself from 3,800,000*l.* to 7,500,000*l.*, which is a larger figure than we can show for our average annual export to Canada over the same period, as is also the case with our shipments of 8,000,000*l.* manufactured goods to Belgium.

Our export trade to British India has only increased 3 per cent. in the period under review.

Our exports of manufactured goods to all Crown Colonies (except Hong Kong and Singapore), and all British possessions (except India and Ceylon) have increased by 2,000,000*l.*, and still just fall short of our exports to Russia.

Our trade to Cape Colony and Natal has increased enormously, from 2,900,000*l.* to 10,500,000*l.*

New Zealand shows an increase of 1,500,000*l.*

Australia has remained stationary, and Canada, in spite of the preferential tariff which was in operation during the whole period 1898–1902, shows a loss of 100,000*l.* compared with the figures of fifteen to twenty years ago.

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5. *The Commercial Relations between Canada and the United Kingdom.* *By* F. Bradshaw.

After an historical sketch of the relations between Canada and U.S.A., and Canada and the United Kingdom, which led to the preferential tariff of 1897, the paper attempts to indicate why the preference was given—as an alternative to the annexation of Canada to U.S.A.—and the value of the preference. From 1890 onwards the rush to Manitoba and the North-West Territories can be traced. Canada's prosperity depends on their prosperity, and her manufacturing population cannot consume their products. Possible markets are Great Britain and U.S.A. The latter country is fast reaching a stage when growth of population must prevent it from remaining a source of our wheat supply, and the price of American wheat will rise until even a tariff of 25 cents a bushel cannot keep out Canadian wheat. The St. Lawrence navigation is the crux of the question. The canals could be easily improved till the cost of transporting a bushel of wheat from Port Arthur to Liverpool is only 12 cents the bushel of 60 lb. If a preference to Canadian wheat is given, the improvement will take place before the American demand arises. If the American demand arises first, the improvement will never take place, as the American market will be the more profitable. Hence the price of wheat here will rise and remain high. Probably a 2*s.*, or even a 4*s.*, duty on foreign wheat would not raise the price in England, as the margin of profit retained by the American grower is too large, and he would fear to face the competition of Canadian wheat.

The preference is valuable to us because it has checked the decline in British exports to Canada, and has actually increased their value. The United States have apparently secured a larger increase than we have since 1897; but the increase is in goods, which, being natural products or raw materials for manufactures, do not pay duty; 50 per cent. of U.S.A. imports into Canada are duty free, as

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compared with 29 per cent. of imports from Great Britain. As to duty-paying goods, $3,000,000 represents roughly the value of the preference to Great Britain in 1902 if we consider the amount of duty paid by Great Britain and U.S.A. respectively in relation to the value of the total duty-paying imports. The increase in the value of British exports to Canada since 1898 has been 11·5 per cent., and this relates to goods under the preferential tariff only. Although the United States have an excess of $25,000,000 over us in exports to Canada, yet this can be accounted for almost to the last dollar by articles in which we do not compete to any great extent, because we cannot. But to our shame be it said that $13,000,000 represents the excess of iron and steel exports, and yet our figures for 1902 are an increase of 100 per cent. on those of 1901. The preference chiefly affects textiles, and here, despite the Dingley tariff, we beat the Americans easily. We have driven them out of the woollen market, and even in cottons we have an overwhelming preponderance. Silk and linen goods tell the same tale. In one market at least we have beaten a protectionist nation, but we have opposed to the Dingley tariff, not free imports, but a preference of 33⅓ per cent. If the preference is withdrawn we cannot hope to retain our advantage, or even a footing, in the Canadian market.

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6. *Some Economic Aspects of the English Colour Industries.* *By* F. EVERSHED.

The exceptional progress of Germany in the coal-tar industries, much more rapid than her general industrial progress, has given the impression that the English aniline-dye trade is not only much smaller and less profitable, both of which are true, but is actually disappearing. The statement is sometimes enlarged from dyes to colour, and even to chemicals generally.

The facts are that our annual export of chemicals increased from 7,639,000*l.* in 1880–1884 to 8,829,000*l.* in 1897–1901 and 9,587,000*l.* in 1902. Germany's export is greater, but only in proportion to her larger population. Her annual rate of increase, however, is greater than ours.

Our annual export of painters' colours and materials increased from 1,256,000*l.* in 1880–1884 to 1,836,000*l.* in 1897–1901.

The figures for coal-tar dyes, averaging 231,000*l.* in 1882–1902, show a decline since the beginning of the period, but the trade has apparently been stationary in value for the last five years. The figures, however, are untrustworthy owing to many sources of error. Translated from values to quantities they show a large increase. Prices have fallen 40 per cent. in the last decade. The industry apparently needs a higher standard of engineering, chemical, and business ability, and in some factories attempts are being made to supply this. The German annual export has grown from 2,500,000*l.* in 1882–1888 to over 4,000,000*l.* in 1896–1902.

The question of the amount of the loss we have sustained by allowing Germany to appropriate the bulk of the coal-tar industries, estimated to produce 10,000,000*l.* annually, is discussed. The loss must be placed at a fraction of that sum, representing the difference between it and the annual value now being produced by the English labour and capital which would have been diverted to the production of dyes, scents, and medicines.

Similarly the annual loss to India by the threatened destruction of her indigo industry by Germany will be the difference between the value of Indian indigo, 3,000,000*l.*, and the value of the sugar and oil which will be produced on the same lands with the same labour. The loss in this case, as in the other, is much less than is commonly supposed.

In other cases where certain industries are appropriated by foreign countries there need be no loss at all, since employment and profit do not depend on a multiplicity of different occupations, but on the most efficient employment of a limited quantity of capital and skill, to obtain the highest returns by exchange in the world's market.

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TUESDAY, SEPTEMBER 15.

The following Papers were read :—

1. *Statistical Methods and the Fiscal Controversy.*[1]

By A. L. BOWLEY, *M.A.*

Much of the present confusion is due to erroneous uses of statistics in argument. The fault is as often in logical method as in the statistics themselves.

i. Figures are taken for one year without reference to the series which precede them. Every series has its own characteristics of 'trend' and 'fluctuation'; the effect of a particular event (*e.g.* the alteration of a tax) cannot be determined without reference to these, and very often cannot be determined at all.

ii. Figures relating to quantities, which are not similar, are added, and the total used as if it were homogeneous; *e.g.* the values of imports and exports are added together.

iii. The distinction between value and quantity in trade statistics is ignored; values are generally used, while quantity is ultimately the more important. Progress may often be shown only by increased quantity, while value is stationary.

iv. The measurement of accuracy is generally ignored. Accurate and inaccurate estimates are added or multiplied, and the sum or product treated as representing an ascertained fact. No sum or product is known exactly, but only as correct to 1, 10, or 50 per cent. Partisan writers by adding different estimates which are mere guesses to quantities accurately known produce opposite results.

v. In the same way a measurement of the change of a part is taken as an adequate measurement of that of a whole. To test this it is necessary to determine *à priori* what quantity should be measured, and then (by the criteria of accuracy) to determine what percentage error is involved by only measuring part. Thus home produce and exports must not be separated when productive progress is in question; and productive progress is not a sufficient measure of general prosperity. In default of complete measurement partial indexes are used, which easily lend themselves to personal bias. A method of testing the growth of national prosperity is suggested.

vi. Statistics, even when accurate, are constantly made to support conclusions which have no logical connection with them.

This analysis suggests certain rules for criticism and subjects for statistical inquiry.

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2. *The Failure of Free Traders to Attain their Ideals.*

By W. CUNNINGHAM, *D.D.*

This paper regards the fiscal question as primarily economic; there is no reason to believe that a change of policy would create new positive ties between the different parts of the Empire. The paper also assumes universal free trade as the ultimate aim, but discusses why there has been so little success in realising it, and how it may be attained. (1) It appears from the views of Jefferson and Hamilton that there was every prospect that the United States would have developed as a free trade country, and the policy of Pitt would have favoured this. But Fox and the English shipowners forced the United States to become protectionists in self-defence. (2) Cobden's anticipations that other countries would follow our example and adopt free trade have been falsified, as each politically distinct nation has preferred to develop an independent and all-round economic life, so far as possible, and the colonies are inclined to pursue a similar course.

There is a real economic danger to England as a manufacturing community, as she is being increasingly cut off from the opportunity of purchasing raw materials (*e.g.* cotton) and food (*e.g.* corn). An increased cotton-supply from our colonies

[1] Published in the *Economic Journal*, September 1903.

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might perhaps be obtained by granting bounties, but a proper food-supply could be developed by taxing the wheat of countries which do not receive our manufactures, and thus giving a preference to those which do. This might lead to a temporary and slight rise of price, but it would give a stimulus to the production of corn in non-hostile countries, and there is reason to believe that it would help to break down the highly artificial protective system in America.

Such retaliation is urgently desirable on political grounds, as the persistence in *laissez-faire* tends to the disintegration of the Empire, and puts a special strain upon the loyalty of Canadians.

The manifesto of economic experts appeared to appeal to the principle of free trade in an illegitimate manner, and to take for granted that an economic principle which is framed on the assumption that all political considerations are neglected, also holds good in all political conditions alike. It is not a question of economic principle, but of *laissez-faire* temperament; the issue is between haphazard drifting and intelligent supervision. We need an Imperial Council of Trade, of an advisory character, to work actively for the introduction of universal free trade, in order to preserve the prosperity of this manufacturing community, and to introduce a wise division of employment throughout the British Empire.

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3. *What is Success in Foreign Trade?* *By* EDWIN CANNAN, *M.A., LL.D.*

The object of foreign trade is to enable the people of a country to get income easier than they could without it. A country is not successful in foreign trade when this object is most fully attained.

It is commonly imagined that relative success in foreign trade can be measured in some way or other by comparison of the import and export statistics published by various Governments, good, bad, and indifferent. But these statistics are often totally untrustworthy for any purpose except that of indicating fluctuations over short periods of time, and if they were trustworthy they would not give us the mere trade of the various countries, but only their external receipts and payments. Their receipts and payments include investments and repayments of capital and interest on capital invested in a country different from that in which the owner of the capital resides. Payments on account of these items constantly quite obscure those which are made on account of trade proper, the exchanging of goods for goods. Further, even if we had to deal only with countries which had no receipts or payments except representing the immediate exchange of goods for goods, and if the statistics were perfectly accurate, we could not judge of the success of different policies by any amount of consideration of the import and export figures. A country's success in foreign trade cannot be measured by the magnitude of its exports, or by the magnitude of its imports, or by the magnitude of the sum of its imports and exports, or by the magnitude of the difference between them, whether considered absolutely or in relation to area population or any other condition that can be suggested. Success is attained when the right things are imported and the right things exported, and import and export figures do not and cannot tell us how far that is the case.

Free traders say that, as things are, the right things are most likely to be imported and exported if the Government abstains from exerting influences against the importation or exportation of particular goods. The protectionists agree in saying that Governments, whether democratic or autocratic, pure or corrupt, ignorant or enlightened, will decide the question what should be exported or imported better at all times and places than private interest; but they give different and often entirely contradictory reasons for their belief at different times and places.

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SECTION G.—ENGINEERING.

PRESIDENT OF THE SECTION—CHARLES HAWKSLEY, M.Inst.C.E.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

SINCE the last meeting of the British Association there has passed from our midst, to the deep regret of all who had the privilege of knowing him, one who, though full of years, actively followed his profession as a Civil Engineer until within a few days of his death. I refer to Mr. Edward Woods, who presided over Section G of the British Association at Plymouth in 1877. Mr. Woods commenced his professional career on the Liverpool and Manchester Railway soon after it was opened for traffic. In 1875 Mr. Woods was invited by the Royal Commission on Railway Accidents to undertake, in conjunction with Colonel Inglis, R.E., an exhaustive series of trials of the different kinds of railway brakes then in use in England, the results of which were recorded in an elaborate and valuable report. These trials were referred to by Mr. Woods in his address as President of Section G. Mr. Woods was President of the Institution of Civil Engineers in 1886–1887, and he died on the 14th June, 1903, at the ripe age of eighty-nine.

Technical Education.

The subject of the technical education of engineers was treated very fully in the interesting address delivered by Professor Perry, as President of Section G at the meeting of the British Association in Belfast last year. This question also received thorough consideration at the meeting of the Engineering Conference held in London in June last, as well as at recent meetings of the Institution of Mechanical Engineers and of the Institute of Naval Architects. The systems in vogue in the United States of America and on the Continent of Europe were on those occasions brought forward in carefully prepared papers and fully discussed. The main points at issue are: (1) whether actual handicraft should be taught in the Technological School or College along with the principles underlying the Engineers' art; (2) whether the year should be divided into periods in one or more of which the science of engineering should be taught, and in another or others of which craft skill should be acquired at works; (3) whether the principles should be first acquired, during a longer or shorter term, leaving experience in applying those principles to be gained at the termination of the course. As regards the first of these suggestions it appears to be in opposition to the judgment of the most experienced teachers. In respect to the second, the Admiralty have carried it out for the last forty years, and with satisfaction to the Service; it is also common in Glasgow, and Mr. Yarrow has included this system in the apprenticeship rules he has recently laid down, whilst it is to be tried experimentally in the Engineering Course at King's College, London. At the Engineering Conference it was determined that the subject was of such importance that its further consideration should be left to a Committee, to be subsequently appointed.

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Since the British Association last met in Lancashire (in 1896) there have been important events and changes in the chief technical institutions of the county. First, there were last year the Jubilee celebrations of Owens College, Manchester, when it received congratulations on its half-century of work from universities and learned societies in all parts of the world. Here, as I need hardly remind you, the engineering laboratory is under the able direction of Professor Osborne Reynolds, F.R.S., who presided over Section G of the British Association at their Meeting in Manchester in 1887. Then, also in Manchester, there is the recently completed and admirable Municipal School of Technology; but as a paper will be read on this subject, and members will have an opportunity of visiting the school and inspecting its engineering laboratory, I will content myself with wishing it every success in the manifold fields of industrial education in which it is engaged. Again, only this year Victoria University has lost a College, and Liverpool has gained a University. At University College, Liverpool, in the Session of 1884–5, a Professorship of Engineering was instituted as a provisional measure. The erection of engineering laboratories and the endowment of the Chair were afterwards provided for by gifts in commemoration of the Jubilee year of the reign of Her late Majesty, Queen Victoria. Professor H. S. Hele-Shaw, F.R.S., was appointed to the Chair in the first instance, a position which he still continues to hold.

This year a Royal Charter has been granted establishing the University of Liverpool, and transferring to it the powers of University College, Liverpool. I think one cannot offer to the University of Liverpool a heartier wish than that it may be as successful in the future as University College, Liverpool, has been in the past, a wish in which I am sure you will all join.

There is yet one other college to which, though not in Lancashire, I should like to make a passing reference, the first to include engineering in its educational curriculum, viz., University College, London. It was originally founded in 1828 under the name of the 'University of London,' and has recently, together with King's College, become merged in the present University of London. The first engineering laboratory was established at University College in 1878, fifty years after the inauguration of the college, whilst a separate chair for electrical engineering was founded in 1885, and an electrical laboratory was added ten years ago. One cannot say farewell to it as it used to be without mentioning the name of Dr. B. W. Kennedy, F.R.S., who was President of this Section of the British Association in 1894 at Oxford, and who has done so much for engineering education.

Before leaving the subject of technical education, I venture to express the hope that in the training of engineering students increased attention will be paid to the combination of artistic merit with excellence of structural design, so that in respect to artistic treatment our engineering structures may not remain so far behind those of our Continental brethren as is unfortunately now frequently the case.

Engineering Standards.

A very important work has been going on quietly and unostentatiously in our midst for some time past, the results of which must affect the engineering profession at home and abroad. I refer to the work of the Engineering Standards Committee, which as many of my hearers know, was appointed in 1901 and is now composed of 178 members, among whom are many Government officials. I alluded to the earlier work of this Committee in my Presidential Address to the Institution of Civil Engineers in 1901, and that work has since been gradually but surely extended. The Committee has received not only the moral but the financial support of His Majesty's Government, and the results of its labours are being adopted by all the leading Government departments.

In addition to the main Committee there are no fewer than twenty-five separate committees and sub-committees engaged on work, covering a wide range of operations, many of the members sitting on more than one committee.

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A few details of the work accomplished and in progress may be of interest. After careful deliberation the Committee published their first series of British standards sections, covering all rolled steel sections used in constructional work, shipbuilding and so forth. The Committee on Rails has just issued the standard sections and specification for British girder tramway rails, and it is now actively engaged in drawing up a series of standard sections of bull-headed and flat-bottomed rails for railway work.

Another committee of a thoroughly representative character is occupied in drawing up a standard specification and standard tests for cement, and a standard specification drawn up by so large a body of our leading engineers, contractors and manufacturers must be of great interest to all those who are called on to specify tests for this material.

The Government of India control to a very considerable extent the working of railways in India, and they have referred to the Standards Committee the important question of drawing up a series of standard types of locomotives for use on the Indian railways. The Committee which investigated this difficult subject has just forwarded its report to the Secretary of State for India. Other committees are preparing standard specifications for locomotive copper fire-box plates and steel boiler plates, which it is hoped will be published at an early date.

The subject of screw-threads is one which has occupied a Committee of the British Association for some years past, and I am glad to learn that the Committee of this Association has been co-operating with the Standards Committee and discussing the question of screw-threads of both smaller and larger diameters, and also considering the cognate subject of limit gauges so essential to all accurate work in mechanical engineering.

Another Committee is dealing with standard flanges, and I understand it is shortly proposed to consider the standardisation of cast-iron pipes.

A very large and influential Committee is engaged on the subject of the materials used in the construction of ships and their machinery, and most valuable information is being collected with a view to the preparation of a standard specification for steel and to the determination of forms for standard test-pieces to be used when testing plates, forgings, castings, and so forth.

There are about half a dozen committees engaged on various important electrical subjects, but as their work will no doubt be referred to in another Section of this Association, I do not propose to make further reference to it here.

In my Presidential Address before the Institution of Civil Engineers in 1901 I raised a note of warning in regard to the stereotyping of design and the consequent cramping of originality. The constitution of the Standards Committee and the professional standing of its members affords a guarantee that its work will accord with the best practice of this country, since those engaged in drawing up the standards are not only in the forefront of engineering practice, but are alive to the necessity for extending the number of standards if and when needed to meet the requirements of the engineer.

National Physical Laboratory.

An outline scheme for a National Physical Laboratory was set forth in 1891 by Sir (then Dr.) Oliver Lodge, F.R.S., in his Address at Cardiff to Section A of the British Association. In his Presidential Address to this Association in 1895 at Ipswich, the late Sir Douglas Galton, F.R.S., emphasised the importance of such an Institution, a Committee of this Association reported in favour of it, and later, when after forwarding a petition to the late Lord Salisbury, a Treasury Committee with Lord Rayleigh, F.R.S., in the Chair was formed, Sir Douglas Galton gave evidence to the effect that if Great Britain was to retain its industrial supremacy, we must have accurate standards available to our research students and to our manufacturers.

In 1901 the National Physical Laboratory was inaugurated at Bushy House, near Teddington, and an annual grant of 4,000*l.* towards its support was made by Government. It is divided into three departments, of which the one dealing with

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all branches of Civil, Mechanical, and Electrical Engineering is chiefly interesting to us in Section G. In this department tests are now undertaken of the strength of materials of construction, of pressure and vacuum gauges, of indicators and indicator springs, and of length gauges and screw gauges, and photomicroscopic investigation is made of metals and alloys, and especially of steel rails.

But beside the ordinary work of testing, various investigations are in progress, such as measurement of wind pressure, elastic fatigue in nickel steel and other materials used by engineers, and the magnetic and mechanical properties of aluminium-iron and other alloys. For the British Association a set of platinum thermometers has been constructed and subjected to stringent tests, and an investigation has been undertaken for the Engineering Standards Committee into the changes in insulating strength of various dielectrics used in motors, transformers, &c., due to continued heating. In the language of Dr. Glazebrook, F.R.S., the Director, who it may be mentioned was previously Principal of University College, Liverpool, science is not yet regarded as a commercial factor in this country, but it is one of the aims of the National Physical Laboratory to bring about the alliance of science with commerce and industry. The expenditure of the National Physical Laboratory is met by an annual Treasury grant of 4,000*l.*; 500*l.* a year from an endowment; fees for tests, now amounting to about 3,500*l.* annually; and from donations and subscriptions.

The Director is anxious that the revenue derived from fees for testing should be largely augmented, and I would urge on engineers, contractors and manufacturers, as well as on private individuals, that they should avail themselves of the opportunity to have tests and experiments of interest to them, and which will be generally accepted as unimpeachable, conducted at this laboratory. I may add that an appeal has been made for further donations and annual contributions, as the funds now at the disposal of the Board of Management are insufficient to carry on the work of the laboratory on a sound financial basis, and I venture to hope that many of those who are interested in the practical applications of science will assist in supporting the work of this national institution.

Intercommunication.

General Progress.

At the commencement of the nineteenth century, Southport, which now has its parks, a promenade, and a pier over three-quarters of a mile in length, its halls, free library, art gallery and science and art schools, and railway connection with all parts of the kingdom, was not even to be found on the maps, the first house having been erected in the year 1792. In 1851 the population of Southport and the adjoining place Birkdale was 5,390, whereas at the census of 1901, Southport had a population of 48,083 and Birkdale 14,197, together 62,280. Here is evidence of great local enterprise, resulting in a development of which its people may be justly proud.

At the commencement of the nineteenth century the population of the United Kingdom was nearly 15¾ millions, at the beginning of the twentieth nearly 41¼ millions. Then there was not a mile of railway in the United Kingdom: now there are about 22,000 miles. Here, too, is evidence not only of the prosperity which has prevailed throughout Great Britain during the century that has passed, but also of the enormously increased demands which have arisen during the same period on the means of locomotion.

It was towards the latter half of the eighteenth century that the formation of good roads was commenced in Lancashire and the adjoining counties by John Metcalf, the blind road-maker, and that Palmer in 1784 introduced mail coaches travelling at from six to seven miles an hour on the main roads. In 1801 the mail coach from London to Holyhead occupied nearly 46 hours on the journey, and the mails reached Dublin on the third day after leaving London. Now the journey from London to Holyhead is performed in 5¾ hours, and Dublin is reached in 9¼ hours after leaving London.

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In 1803, just one hundred years ago, Telford reported to the Government on the state of the roads, and as a result the great road to Liverpool from the Metropolis and the other great highways were constructed. It was enlightened wisdom that eighty years ago placed intercommunication in the forefront of the definition of engineering; it still maintains that position, and I purpose to say a few words on the present aspect of the question.

Road Traffic—Motors.

Speed in locomotion appears to be now the first consideration, whether as regards mails, passengers, or goods. I would refer in the first instance to locomotion on our main roads. Here three or four classes of machines appear to be ambitious to drive pedestrians, horsemen, and horse-drawn vehicles off the road.

The first practical steam carriage was used by Trevithick in the year 1802; and now, a hundred years later, it is found that for the traction of heavy loads on the main roads steam is still most suitable. The points of importance in connection with traction engines and their trailers are their speed, weight, and width; of course, there is no question that, as regards facilitating traffic, the large heavy waggon replacing many smaller horse-drawn ones will be found a boon. Mr. E. R. Calthrop, M.Inst.C.E., one of the founders of the Liverpool Self-propelled Traffic Association, is opposed to any weight restriction, but it must be remembered that the momentum of heavily laden waggons drawn by a powerful traction engine at the maximum speed of five miles an hour, is very great, and causes uncomfortable vibration in the houses along the main thoroughfares of our towns; on the other hand, light traction engines are now being successfully used, drawing from four to five tons of market produce through the streets of London without causing undue vibration, and at a cost, I am informed, of about one-half that of horse traction.

But a far more important question is that of the speed of motor cars along our public thoroughfares. The struggle to maintain a trophy at home, or to regain it from abroad, is one in which every inhabitant of this country sympathises. The great Gordon-Bennett Cup Race in July last redounded to the credit of the Automobile Club of Great Britain and Ireland, who made and carried out the arrangements and were at considerable pains to find a suitable course in a sparsely inhabited district; every measure which experience has shown to be needful having been taken to prevent accident. The race was decidedly international in character, French, Germans, Americans, and English contesting for the prize; and in heartily congratulating the German Automobile Club on their success, it may be noted that M. Jenatzy covered a distance of 327½ miles in 6 hours 39 minutes, or at the rate of 49¼ miles an hour, though he attained to a speed of 61 miles an hour between the points of control. Even this speed was exceeded at a trial in Phœnix Park, Dublin, when Baron de Forest attained to a rate of 86 miles an hour. But between racing speed and ordinary travelling speed there is necessarily a great difference, and our twenty miles maximum on country roads is in excess of that allowed in France, where it is now fixed, though I believe not enforced in the open country, at 18½ miles, and at 12½ miles where there is much traffic. The two classes of motors used for higher speeds are the petrol and the electric. The former are mainly internal-combustion engines; having to be light, they run at the comparatively high speed of 800 revolutions per minute. They are generally used in connection with bicycles, tricycles, or light carriages. They have also been used for light vans and coaches, and successful trials have been made with self-propelled lorries for military purposes, and by local authorities for watering and dust collecting. Their application to omnibuses has not proved economical, owing to the difficulty of providing pneumatic tyres for such heavy vehicles.

The electric motor depends on storage batteries; those in general use are of Planté's lead-couple type. Like the petrol motor, the electric motor is rather a luxury; most of the automobile carriages used in London are of this class; there is liability of injury to the batteries by over-discharging them. Colonel Crompton, in a paper recently read at the Engineering Conference, suggested the use of

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'standardised accumulators,' to be supplied to the owners of electrical vehicles at depôts on production of a subscription ticket, and the Engineering Standards Committee has appointed a sub-committee to consider the question. Motor cars are now used by some of the railway companies as feeders to their lines, and also in competition with tramway lines.

The increasing use of motor cars renders more than ever necessary the regulation of traffic in crowded thoroughfares, a subject which will doubtless be dealt with in the paper on 'The Problem of Modern Street Traffic,' which Colonel Crompton is about to read before this Section of the British Association.

The use of motor-driven vehicles for road traffic is so intimately associated with improvements in prime movers that it will interest the members of this Section to be reminded of the opinion expressed more than twenty years ago by Sir Frederick Bramwell, F.R.S., Past President Inst.C.E., who presided over the Meeting of the British Association at Bath in 1888. In a paper read before this Section at the Jubilee Meeting of our Association at York in 1881, and afterwards printed *in extenso*, Sir Frederick Bramwell said: 'However much the Mechanical Section of the British Association may to-day contemplate with regret even the mere distant prospect of the steam-engine becoming a thing of the past, I very much doubt whether those who meet here fifty years hence will then speak of that motor except in the character of a curiosity to be found in a museum.' In a letter addressed to the President of this Association on July 2 last, Sir Frederick Bramwell drew attention to the largely increasing development of internal-combustion engines, and expressed a feeling of assurance that, although steam-engines might be at work in 1931, the output in that year would be small of steam as compared with internal-combustion engines.

To keep alive the interest of the Association in this subject, Sir Frederick Bramwell has kindly offered, and the Council has accepted, the sum of 50*l.* for investment in 2½ per cent. self-accumulative Consols, the resulting sum to be paid as an honorarium to a gentleman to be selected by the Council to prepare a paper having Sir Frederick's utterances in 1881 as a sort of text, and dealing with the whole question of the prime movers of 1931, and especially with the then relation between steam-engines and internal-combustion engines. That paper will doubtless prove to be a very valuable contribution to the proceedings of this Association, and one can only regret that many of those assembled here to-day cannot hope to be present when it is read, and to listen to an account of the nearest approach which has then been made towards the production of a perfect prime mover.

Electric Tramways and Light Railways.

I now pass to the application of electricity to tramways, and in so doing may quote from the careful expression of opinion given in this town from this Chair twenty years ago by the late Sir (then Mr.) James Brunlees, President of the Institution of Civil Engineers: 'The working of railways by electricity has not advanced further than to justify merely a brief reference to it in this paper as among the possibilities, perhaps the probabilities, of the not distant future.'

It was stated in a paper read by Mr. P. Dawson in April last before the Tramways and Light Railways Association, that the total route-length of electric tramways and light railways in the United Kingdom, either completed, under construction, or authorised, amounted at the end of last year to 3,000 miles, the length of single track being 5,000 miles, on which some 6,000 cars were running.

It cannot, in my opinion, be regarded as being fair to the railway companies—which have to pay large sums of money for the land on which their lines have been constructed—to have to compete with tramways which are laid along the public roads without any payment being made for their use. The roads are disfigured by aërial conductors and the supporting posts by which the electric current is conveyed to the cars, except in those comparatively rare instances in which the conduit system is used; nor can it be denied that tramways greatly interfere with the use of the roads for ordinary traffic. The effect of electrolytic action on iron pipes laid beneath the roads is still undergoing investigation.

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Railways.

Turning now to railways, it may be noted that on some of the principal lines in Great Britain the length of the runs without a stop is being increased in the case of fast trains, the speed of which is in some cases from forty-eight to fifty-nine miles an hour.

Railway companies are turning their attention to the introduction of electric traction wherever it can be beneficially used, as for instance on the Mersey Railway, the North-Eastern Railway between Newcastle-upon-Tyne and Tynemouth, and the Lancashire and Yorkshire Railway between Liverpool and Southport. With the object of facilitating the introduction and use of electrical power on railways, Parliament has passed an Act entitled the 'Railways (Electrical Power) Act, 1903,' which will come into operation on January 1 next.

The electrical service on the Mersey Railway has now been in regular and uninterrupted operation since the beginning of May in the present year. Trains are run at three-minute intervals, there being 750 trains in all between 5 A.M. and 12 midnight; and as it is the first example of a British steam railway converted to the use of electric traction, a short description of it cannot fail to be of interest.

The Mersey Railway was first opened for traffic on February 1, 1886, and was afterwards extended at both ends, the last extension to the Liverpool Central Station being opened for traffic in January 1892. With steam locomotives, largely owing to the want of adequate ventilation, the railway was not a success. Electrification was decided upon, and in the latter part of 1901 the British Westinghouse Electric and Manufacturing Company, Limited, undertook the entire contract. The length of the railway is about 3¾ miles, and there are gradients in the tunnel below the river of 1 in 27 and 1 in 30.

The power station is at Birkenhead, and contains plant aggregating over 6,000 horse-power, comprising three engines of the Westinghouse-Corliss vertical cross-compound type.

The generators are all three alike, mounted on the engine shaft between the cylinders. They are standard Westinghouse multipolar machines, of the double-current type, of 1,250 kilowatts capacity. Direct-current is collected from the armature at 650 volts, no alternating current being used at present.

Leads are carried below the floor from the machines to a switchboard, from which are controlled the main generators, the auxiliary lighting sets, battery, booster, and feeders. The battery consists of 320 chloride cells connected in parallel with the generators through a differential booster, and charge or discharge according as the line load is light or heavy. They have a capacity of 1,000 ampere-hours, and a momentary discharge capacity of 2,000 amperes.

The auxiliary sets, two in number, are for lighting purposes, and yielding direct current at 650 volts, are available in case of need to supply current to the main traction circuits. 210 volt incandescent lamps are used for lighting, arranged in groups of three in series.

The feeders are carried from the switchboard down the ventilation shaft to feed the insulated electrical collector rails, which are placed in the space between the up and the down lines, and somewhat above the level of the rails, an insulated return collector rail being placed between each pair of rails. A train consists of two motor cars, one at each end, and from one to three trailers as required, depending on the amount of traffic. The motor cars each carry an equipment of four Westinghouse motors of 100 horse-power, making 400 horse-power per car, or 800 horse-power per train. These motors are all controlled in unison from the motorman's compartment at either end of the train by means of the Westinghouse multiple controlled system, which has worked from the start without a hitch.

In conclusion, it may be noted that every precaution has been taken against fire. The electrical equipment is all thoroughly fireproof, and the motorman's

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compartment is encased in asbestos slate, cutting it off completely from the remainder of the train.

Of tube railways with electric traction there are three now working in London, two between the City and the south side of the River Thames, using the ordinary two wire 500 volts continuous current system, and another (the Central London) extending from the City to Shepherd's Bush, using the composite system. This railway conveyed during the year 1902 no fewer than 45 million passengers. There are eight other tube railways now in course of construction in London. The recent terrible catastrophe in Paris must serve as a warning in the future equipment of such lines where currents at high tension are employed, and where short-circuiting may bring about disastrous results.

A paper will be read before this Section by Mr. F. B. Behr on the authorised Manchester and Liverpool Express Railway, which is intended to be constructed on the Mono-rail system, and to be worked electrically.

Canals.

Concurrently with the construction of roads in this country was the formation of canals, as a means of inland communication, mainly for the carriage of minerals and merchandise, though they also conveyed passengers by express boats. The only recent structure of this character in the United Kingdom is the famous Manchester Ship Canal, with which the name of Sir E. Leader Williams, M.Inst.C.E., is associated. This, however, is hardly a canal in the sense in which that word was employed by Brindley, 'the father of inland canal navigation in England,' as the largest amount by far, in the proportion of 10 to 1, is its seaborne, as compared with its local traffic. It is interesting to notice that a very important wheat trade is being carried on with India, exported both from Bombay and Kurrachee. The seaborne traffic and the barge traffic for 1894 was 686,158 tons and 239,501 tons respectively, and has during eight years increased, until in 1902 it had reached 3,137,348 tons and 280,711 tons respectively. The most interesting recent development of the works is the new Dock now in course of construction, with its five sets of transit sheds, which are being built on the Ferro-Concrete system.

Ships.

The intercommunication of the nations of the world is largely dependent on the navigation of the ocean. The first vessel to cross the Atlantic fitted with steam power was the 'Savannah,' of about 300 tons, which arrived at Liverpool from Savannah, in Georgia, in thirty days, partly under steam and partly under sail. Ocean steam traffic has been extending ever since. Two years ago I had occasion, in connection with my Presidential Address to the Institution of Civil Engineers, to collect some statistics with regard to shipping, and found that according to Lloyd's Register the largest British vessels then afloat were the twin-screw steamers 'Oceanic,' of 17,274 tons, and the 'Celtic,' of 20,904 tons, both gross register, built for the White Star line, and regularly making the passage between Liverpool and New York in seven days and eight days respectively; and the 'Celtic' is still the largest mercantile steamship afloat, the tonnage of the new German steamer, 'Kaiser Wilhelm II.,' being 19,360 tons gross register.

Unfortunately these fine ships, with many others, are now no longer owned in this country, although still flying the British flag. The latest German steamer on the American line, together with others recently launched from the Vulcan Works at Stettin, have maintained a speed averaging over 23 knots, whilst the Cunard Company's liners—still, happily, English—the 'Campania' and 'Lucania,' built ten years ago, average 22 knots. This company is under contract with the Government to build two liners to maintain an average speed of 24½ knots. The secretary of 'Lloyd's Register of British and Foreign Shipping' has kindly supplied me with a list of the steamers of 10,000 tons and upwards which have been

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launched in the United Kingdom between 1900 and June 1903. It is given in aggregate below:

Year	Number of ships	Aggregate gross tonnage
1900	8	95,275
1901	8	107,396
1902	7	98,505
1903 (six months to June 30)	6	67,600 (approximate)

In the Address already referred to I mentioned the application as having been then recently made of the Parsons steam turbine to H.M. torpedo-boat destroyers. The South-Eastern and Chatham Railway Company's new steamer 'The Queen' has been fitted with this class of engine of latest design. There is a central high-pressure turbine, driving its shaft at 700 revolutions a minute, and two side low-pressure turbines, each driving its separate shaft at 500 revolutions a minute. The steamer is 310 feet long, and is now running successfully in the service between Dover and Calais.

For some time past much attention has been paid, more especially in France, to the perfecting of submarine vessels for the purposes of naval warfare, but it cannot yet be said that they have passed beyond the experimental stage, although the advance made has been such as to cause our Admiralty to order several additional vessels of the submarine type. These vessels are to be propelled by internal-combustion engines when on the surface of the water and by electric motors when submerged.

Aëronautics.

Another of the attempted means of locomotion is that of aërial navigation. How little we appear to have advanced beyond where we were fifty years ago, when on September 24, 1852, that eminent French engineer, Henri Giffard, succeeded during an experimental ascent in Paris in driving a ballcon against the wind for a very short distance, although on October 19, 1901, M. Santos Dumont was successful in navigating his balloon from St. Cloud round the Eiffel Tower in Paris and back to the spot where he had started only half an hour previously. Many have been engaged in this so far unsolved problem of aërial navigation, but there is one of whom we seldom hear. I will quote what Mr. Janssen said in his Presidential Address to the International Aeronautic Congress, held in France on September 15, 1900, regarding Mr. Langley, Correspondent of the Institute of France and Secretary of the Smithsonian Institution at Washington. 'Independently of the fine and profound researches of this scientist upon the resistance of air, Mr. Langley has constructed an aeroplane which has progressed and has sustained itself during a time notably longer than any of the apparatus previously constructed.'

In the last report of the Smithsonian Institute, that for 1901, it is stated that this steel flying-machine had a supporting area of 54 square feet, a weight of 30 lb., developed 1½ horse-power, and repeatedly flew from one-half a mile to three-quarters of a mile. I cannot close this portion of my Address without referring to the death on 7th February last, in the ninety-fourth year of his age, of that eminent scientific aëronaut, Mr. James Glaisher, F.R.S., who in 1863 made his famous ascent to an altitude of seven miles, and who described at the Newcastle-upon-Tyne Meeting in that year, in an evening lecture, the balloon ascents made for the British Association.

Wireless Telegraphy.

In addressing this Section I feel that I ought to say a few words on the subject of 'wireless telegraphy.' With regard to signalling Signor Marconi certainly seems to have made progress. In January, 1901, signals were conveyed from Pold in Cornwall to the Isle of Wight, a distance of 200 miles, and in December of the

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same year, between Cornwall and St. John's, Newfoundland, a distance of 2,000 miles. In the year 1902 signals were transmitted from England to the Baltic and the Mediterranean, which had thus passed over both sea and land. It seems to be not improbable that signals can be sent any distance, so long as the sending station can develop sufficient energy. The question of 'syntonism,' by which it is proposed to assure the secrecy of messages, appears to be still *sub judice*, but is undergoing further investigation.

There appears to be a practical field for the development of 'wireless telegraphy,' more especially where ordinary telegraphy cannot be applied, as, for instance, between shore and ships at sea or between one ship and another.

The Marconi Wireless Telegraph Company have obligingly furnished me with a list of eighteen land stations fitted on the Marconi system for commercial ship signalling, together with a list of forty-three passenger-steamers already furnished with the Marconi apparatus, thus affording evidence of its application to practical purposes.

The system of 'wireless telegraphy' by Sir Oliver Lodge and Dr. Muirhead has, I understand, been fitted to cable steamers of the Eastern Extension Telegraph Company, to enable communication to be made with their cable stations.

Sewage Disposal.

The bacterial treatment of sewage is receiving much attention, and by the courtesy of Mr. J. Corbett, M.Inst.C.E., the Borough Engineer of Salford, I am enabled to make a brief reference to the system of sewage treatment now carried on at the Salford Corporation Sewage Works, adjoining the Manchester Ship Canal. Twenty years ago the works were constructed with precipitation tanks for lime treatment of the sewage. After fourteen years of experiments with various precipitation and filtration processes, ten of the original precipitation tanks were formed into two large tanks in which precipitation takes place with the aid of milk of lime and salts of iron. The other two original tanks were converted into six roughing filters containing 3 feet in depth of fine gravel, to intercept particles which have escaped the precipitation process, and which would tend to choke the final filters. The final purification is on bacteria beds or aërated filters, with an open false floor of perforated tiles and large open culverts giving constant ventilation through the beds, some of which are filled to a depth of 5 feet and others to a depth of 8 feet with crushed clinkers of from $\frac{1}{16}$ inch to $\frac{3}{4}$ inch diameter. The liquid is 'rained' on to the surface by spray jets, and the beds are used generally in shifts of two hours each for eight hours a day in dry weather and for twenty-four hours during heavy rainfall. An average quantity of from 400 to 500 gallons of sewage per square yard per day is treated with satisfactory results.

Liverpool Docks.

Although there may seem little of interest in the vast areas of sand which separate Southport from the sea, yet if the whole sea coast from the Dee to the Ribble be taken into consideration, there are few areas of greater interest to the hydraulic engineer than these rivers with the shores that bound them, and few in which stranger changes in land level have occurred within historic times. In the Itinerary of Ptolemy, the Ribble is named immediately after the Dee, the Mersey being omitted altogether.

At the meeting of this Association at Liverpool in 1896, reference was made to these matters, not only by the President of this Section, Sir Douglas Fox, Past President Inst.C.E., but also in papers read, one of which, by Mr. T. M. Reade, F.G.S., is entitled 'Oscillations in the Level of the Land, as shown by the Buried River Valleys and Later Deposits in the neighbourhood of Liverpool.'

Evidence of the gradual sinking of the land is given by the very interesting discovery in 1850 of a Roman bridge at Wallasey Pool, Birkenhead. After excavating fourteen feet, the workmen came upon a bridge of solid oak beams, supported in the centre by stone piers and resting at the ends upon the solid rock at

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the sides of the creek. The length of the bridge was 100 feet and its width 24 feet, and the beams were each 33 feet long, 18 inches wide, and 9 inches thick; there were 36 beams formed into 12 compound beams, each 27 inches in depth. Careful drawings of this bridge were made by Mr. Snow, an engineer employed on the work then in progress. The drawings show that the rocky bed of the stream was some 13 feet below the bridge, which was itself about 16 feet below present high-water level.

Formerly Liverpool was one of the ports subordinate to the Comptroller of Chester, and is styled in the Patent 'a creek in that port.'

The first Act of Parliament authorising the construction of Dock works was obtained in 1709, and in 1853 the water area of the docks had been increased to 178 acres. Since 1853 the progress has been much more rapid, especially within the last thirty years. The total area of the docks and basins at Liverpool and Birkenhead is now 566 acres, whilst in connection therewith there are rather more than 35 miles of quayage. The marked tendency in recent years to increase the length, beam, and depth of ocean-going steamers has necessitated the provision of dock accommodation for a much larger class of vessel than formerly existed; and during the last decade works of great magnitude have been successfully carried out by the Mersey Docks and Harbour Board, under the able direction of the late Mr. G. F. Lyster, M.Inst.C.E., and, since his death, of his son, Mr. Anthony G. Lyster, M.Inst.C.E. In the northern section a new graving-dock has been constructed, extensive additions have been made to the Canada and Huskisson Docks, whilst the difficult work of constructing new river entrances has also been satisfactorily completed. In the southern section, the Queen's Dock has been enlarged and other important additions have been executed and brought into use.

To convey some idea of the magnitude of the works executed, it may be mentioned that the amount expended by the Dock Board in the extensions above indicated exceeds 1,750,000*l*.

The largest lock connected with the port of Liverpool is the Canada, 600 feet long by 100 feet wide, the sill being 14 feet below the datum of Old Dock sill, which datum is 4 feet 8 inches below Ordnance datum, or mean sea-level. Two large river-entrance locks into the Brunswick Dock are now approaching completion, the larger lock having a length of 360 feet and a width of 100 feet, with a sill 19 feet 6 inches below the datum of Old Dock sill.

One of the striking features in connection with the port of Liverpool is the difficult and extensive work connected with the dredging operations at the Mersey Bar. Since the commencement in 1890, to August 1903, no less than 72,000,000 tons of material have been dredged and removed from the Bar and sea channels, and the average quantity for the last five years has been in round figures, 7,000,000 tons per annum. The total tonnage of the port for the year ended July 1, 1903, was 13,308,305, and the receipts therefrom amounted to 1,185,066*l*., exclusive of graving dock and other rates.

Irrigation.

This being the first Meeting of the British Association since the completion of the Assuan dam, which I had the opportunity to inspect when visiting Egypt in the early part of this year, I should like to devote to it a short portion of my Address. Those who desire to learn all about that work in detail I would refer to the papers (to which, indeed, I am indebted for my information on the subject) read before the Institution of Civil Engineers on January 27 last by Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., who had charge of the work on behalf of the Egyptian Government from its commencement in 1898 until December 1901, and by Mr. F. W. S. Stokes, M.Inst.C.E., managing director of Messrs. Ransomes & Rapier, of Ipswich, who undertook the manufacture and erection of the sluices and lock-gates.

The Nile reservoir has been constructed for the purpose of impounding the water of the River Nile during the winter months, and discharging it in the months of May, June, and July, so as to supplement the ordinary flow of the

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river, and thus enable land to be irrigated which would otherwise receive either no water, or an insufficient supply. The situation chosen for the dam was the head of the Assuan cataract. There were various reasons for the choice: there was a wide section of the river, the waterway being about seven-eighths of a mile, thus permitting the construction of sufficient sluices at different levels to discharge the whole volume of the Nile in flood without weakening the dam by placing them too close together; the height of the dam would be moderate; the site chosen seemed to promise good rock foundation throughout, and there were several natural channels when the water was low, each of which could be dealt with separately if desired.

Arrangements had to be made to house and feed a population of 15,000; offices, workshops, a hospital, and other temporary buildings had to be erected, and a line of railway about 3 miles in length had to be constructed to connect the railway from Luxor to Assuan with the works at the dam. This preliminary work was carried out in 1898, and on February 12, 1899, H.R.H. the Duke of Connaught laid the foundation-stone of the dam.

To enclose the site of the permanent masonry dam, and to render it dry for the purpose of excavation and laying the masonry, temporary dams, known in Egypt as 'sudds,' had to be formed both above and below the site of the permanent dam. At low Nile the river at the Assuan cataract divides itself into five channels, and this work was done in five sections. The down stream 'sudds' were first made, and consisted of stones. After the rush of water had been thus stopped, the up-stream 'sudds' were formed of bags of sand.

It was found that the rock on the site of the dam was decomposed. The importance of a solid rock foundation was paramount, and to obtain it the excavation had to be carried down to a considerable depth, necessitating the removal of double the amount of material which had been contracted for, and the construction of nearly one and a half times the quantity of masonry that had been anticipated. The masonry, consisting of local granite set in Portland cement mortar, was commenced in May 1900, was carried on vigorously during two working seasons in which the Nile was abnormally low, and was finished in June 1902, less than 3½ years after the first stone was laid, and one year before the expiration of the contract time. The dam is nearly 1¼ miles in length, and the difference between the surface of the water on the up-stream side and that on down-stream side is 65½ feet when the reservoir is full. The masonry is pierced by 180 sluices, of which 140 are 23 feet high by 6 feet 6¾ inches wide, and 40 are 11 feet 6 inches high by 6 feet 6¾ inches wide.

The construction of the dam having closed the river to navigation, provision for the passage of vessels was made by means of a canal formed on the west bank of the Nile and having a succession of four locks.

The capacity of the Nile reservoir when filled to the top water height of 348 feet above mean sea level is about 37,600 million cubic feet, a quantity which might have been greatly increased had not the desire to preserve the Temple of Philæ prevented the raising of the water to the level originally proposed. Even now many portions of the temple or its adjacent buildings are partially submerged.

It is anticipated that by allowing the whole volume of the Nile to pass through the sluices when most laden with mud during floods, the silting up of the reservoir to any considerable extent will be prevented. The cost of the works was nearly 2,450,000*l.* or about 10*l.* per million gallons of water impounded.

The original surveys and designs for the works were prepared by Mr. Willcocks (now Sir William Willcocks, K.C.M.G.), under the instructions of Lord Cromer and Sir William Garstin, Sir Benjamin Baker, K.C.B., K.C.M.G., F.R.S., Past President Inst.C.E., being the consulting engineer. On the retirement of Mr. Fitzmaurice, he was succeeded by Mr. C. R. May, M.Inst.C.E., as engineer in charge. The work was carried out by Messrs. John Aird & Co., as contractors, Mr. John A. C. Blue, Assoc.M.Inst.C.E., acting as their agent.

All concerned in the inception and execution of this great undertaking are to be congratulated on its successful and speedy completion, in the face of the many difficulties which were encountered and overcome.

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Water Supply.

To everyone a plentiful supply of good water is not only a luxury, but almost a necessity of existence, yet how few even amongst the more intelligent of the millions who are accustomed to find such a supply ready to hand at the nearest tap have more than a very imperfect notion of the works that have to be constructed to obtain it, or the daily care and attention given to secure and maintain its purity, to ensure its efficient distribution, and to prevent its waste by careless, ignorant, or reckless consumers. It may therefore not be out of place that when the chair of this Section of the British Association happens, as now, to be occupied by one whose professional life has been largely associated with waterworks undertakings, he should address you on that subject, and endeavour briefly to direct attention to some of the main features of waterworks construction and management. In following that course I shall, however, necessarily have to describe what is already well-known to at least a portion of my audience, on whose indulgence I must therefore rely.

Water supplies may be divided into two main classes, namely, 'Gravitation' and 'Pumping.' In some instances a combination of gravitation and pumping is resorted to, especially in those cases in which the more elevated portions of the district to be supplied are situate above the gravitation level. In selecting a suitable source of supply the main points for consideration are the *quantity* and the *quality* of the water. The quantity should be such as will not only suffice to meet the requirements throughout the most protracted periods of drought and frost of the existing population to be served, but should provide for the probable growth of that population during a reasonable number of years to come. The quality of the water selected should be the best that can be obtained, having due regard to considerations of expense. The question of the altitude being sufficient to permit of a supply by gravitation is of far less moment than those of quantity and quality, because the difference in cost between water derived by gravitation and that obtained by pumping is, in the United Kingdom, less than is generally supposed; indeed, contrary to popular belief, gravitation water is frequently more costly than pumped water, owing to the much greater capital outlay usually incurred in the construction of the works for storing and conveying it.

Gravitation works may be divided into three classes, namely, those in which water is taken directly from a spring or stream without storage, those in which it is taken from a natural lake, in which case the surface level of the water is usually raised so as to increase the capacity of the lake as at Thirlmere, and those more numerous cases in which the water of a spring is impounded in an artificial reservoir generally formed by the construction of an earthen or masonry dam across the valley along which flows the stream to be taken.

In the more populated portions of England it is becoming more and more difficult to find an unappropriated gathering ground available as a source of water supply. The gathering ground, or drainage area as it is frequently termed, should either be free from human habitations and other sources of possible pollution, or any pollution arising therefrom should be capable of being efficiently disposed of by removal from the area of the gathering ground or otherwise.

The gathering ground must also possess a site suitable for the formation of an impounding reservoir. When this has been selected it next becomes necessary to ascertain the amount of the available rainfall, as recorded by rain-gauges situate in the drainage area or its immediate vicinity, or where these are not available, as deduced from the returns obtained from more distant rain-gauges, care being always taken that some at least of the gauges have been observed for a sufficient number of years to enable the true average rainfall to be determined. To store the whole of the water flowing from a gathering ground during a cycle of wet years in order to utilise it during a cycle of dry years would entail the construction of reservoirs of enormous capacity, at a cost incommensurate with the object to be attained; it is therefore customary to make them of such size as to enable the supply to be maintained without risk of failure throughout the three driest consecutive years, the mean annual rainfall of which years generally amounts to

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about four-fifths of the average taken over a long period—say, forty or fifty years. From the mean rainfall of the three driest consecutive years a deduction must be made for loss by evaporation, which is usually between twelve and sixteen inches. The result is known as the available rainfall, and represents the quantity of water which can be drawn continuously from an impounding reservoir without fear of failure in the driest years. But the whole of this water can rarely be abstracted from a stream without injuriously affecting mill-owners or other riparian owners on the stream below the reservoir; therefore they have to be compensated for the injury they sustain. This is sometimes done by payments in money, but where the mills on the stream are numerous it is generally more economical to make compensation in water delivered into the stream immediately below the reservoir, because the same water compensates each mill in succession as it flows down the stream.

It has now become an accepted principle that one-third of the available rainfall flowing down a stream in a regulated quantity day by day throughout the year is of greater benefit to the mill-owners (with few exceptions) than the whole of the rainfall allowed to flow in the irregular manner in which it is provided by nature. This compensation water is discharged from the reservoir into the stream either during certain hours on working days or by a uniform flow throughout the twenty-four hours of every day; a method now frequently demanded by County Councils on so-called sanitary grounds, but which is in my opinion not infrequently detrimental to the interests of mill-owners without a corresponding advantage to the public.

Where compensation in water is given there remains for distribution in the district to be supplied a quantity equal to only two-thirds of the *available* rainfall.

Assume for the sake of illustration a case in which the gross annual rainfall is 40 inches. Then we have:—

	Inches
Gross annual rainfall	40
Deduct to arrive at the mean annual rainfall of the three driest consecutive years—say one-fifth of forty	8
Mean annual rainfall of three driest consecutive years	32
Deduct for evaporation, say	14
Available for supply if no compensation water be given	18
Or if compensation water be given *deduct* one-third	6
Leaving available for supply	12

Having now ascertained the amount of the rainfall available for the supply of the district, it remains to be seen whether or not the area of the gathering ground above the reservoir is sufficient to give the required quantity of water. If it is not, the area may in some cases be extended by means of catch-waters in the form of open conduits cut along the sides of the valley below the embankment of the reservoir, and at such an elevation as will enable them to discharge the waters they collect into the reservoir above its top water line.

Almost all waters derived from gathering grounds are much improved by filtration before use for potable purposes. In some cities and towns in this country, more especially in Lancashire and Yorkshire, the benefit derived from filtration has not been sufficiently appreciated, and the water is still delivered into the houses unfiltered; but I am of opinion that the time will come when nearly every town of importance supplied with water derived from gathering grounds will adopt filtration, for it not only removes matters in suspension but it also diminishes the discoloration due to peat which is to be found in most moorland waters.

Reservoir dams in Great Britain consist either of earthen embankments or masonry walls. Of the former, examples of considerable size may be seen at the reservoirs of the Manchester Waterworks, designed by Mr. J. F. Bateman, F.R.S., Past President Inst.C.E., who was President of Section G of the British Association at the Manchester Meeting in 1861; and at the Rivington reservoirs of the Liverpool Waterworks, designed by my father, the late Mr. Thomas Hawksley, F.R.S.,

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Past President Inst.C.E., who was President of this Section at the Meeting at Nottingham in 1866.

Earthen embankments are formed of the most suitable materials to be obtained by excavation in their neighbourhood; the water is retained by a wall of watertight clay puddle forming the core of the embankment, extending for its whole length and continued at each end into the natural ground forming the hillsides. This puddle core has to be carried down into the ground until watertight strata be met with, occasionally necessitating a puddle trench having a depth of 80 feet or more below the bottom of the valley and 200 feet or more in depth in the hillsides. Where the strata forming the sides of the valley are not watertight, it is necessary to continue the puddle core along the sides of the reservoir by means of wing trenches. The determination of the depth and extent of the puddle trench in order to secure the watertightness of the reservoir is one of the most difficult and anxious duties of the engineer on whom rests the responsibility of its construction. In forming his judgment he has to rely entirely on his experience for guidance, this being one of those matters which cannot be learnt at an engineering school or even in an engineer's office. How much depends on the exercise of a wise and trained judgment may be understood when it is realised that an error in this respect may result in very costly works having to be subsequently undertaken to stop an escape of water which might in the first instance have been prevented by a comparatively small outlay.

Provision has to be made for the passage of flood-waters during the construction of the embankment. This is ordinarily effected by the construction at about the level of the stream of a tunnel of sufficient diameter to convey with only a slight head the volume of water produced by the greatest flood which experience has taught us to anticipate. This tunnel is sometimes formed beneath the embankment, but preferably, where the circumstances are favourable, it is carried through the natural ground near to one end of the embankment. A shaft is built in connection with the tunnel, in which, after the embankment has reached its full height, are placed the outlet valves of the reservoir.

It is of the utmost importance that ample provision should be made for carrying off the flood and other surplus waters coming from the gathering ground when the reservoir is full, for if this be not done serious consequences may ensue, including the washing away of the embankment with resulting destruction of property and even of life. The surplus waters sometimes fall down a shaft erected within the reservoir, and make their escape by means of the tunnel previously mentioned, but more frequently they flow over a masonry weir and reach the stream below the embankment by means of a bye wash formed in the hillside. In my opinion the latter method is in most cases to be preferred, as being free from the risk of blockage by ice to which the shaft and tunnel are liable. Engineers are occasionally reproached with extravagance in the magnitude of the provision made for the escape of flood waters, but it must always be borne in mind that a *maximum* flood has to be provided for, such a flood as may occur only once in twenty or thirty years, but which must find a means of escape when it does occur, without danger to life or property.

Masonry dams are not so frequent in this country as earthen dams, partly by reason of their greater cost and partly because the geological conditions are generally not favourable to their formation, for not only do they require a supply of suitable stone near to hand for their construction, but they also need an incompressible foundation, such as rock or very strong shale. Any irregularity in the compression of the foundation occasioned by the weight of the dam would be liable to fracture the masonry of which it was built.

In the case of masonry dams a tunnel for the passage of flood waters during construction is formed at a suitable level in the masonry of the dam, and after completion of the work they are generally allowed to pass over the top of the dam for the whole or a portion of its length, thus obviating the necessity for and the cost of an independent bye wash.

Whilst masonry dams have the advantage over earthen dams of not being liable to be breached by a waterspout, I am not aware of any case in which an

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earthen dam has been destroyed in that manner, and so far as I am able to form an opinion the accidents due to other causes have been as frequent in the case of masonry dams as in that of earthen dams. The destruction of masonry dams has in some instances been the result of too great reliance having been placed on theoretical calculations, without sufficient allowance having been made for the many defects in material and workmanship which might occur in a work of that kind. It was the opinion of the late Mr. Thomas Hawksley that in some cases the destruction of masonry dams had been occasioned by the neglect of the effects of uplift due to the pressure exerted by water finding its way beneath the bottom of the dam, a possible condition which he was very careful to take into account when designing the masonry dam of the Vyrnwy reservoir of the Liverpool Waterworks.

Examples of large masonry dams in the United Kingdom may be seen in that constructed by Mr. G. H. Hill at Thirlmere Lake, from which the city of Manchester is partly supplied with water. Also at the Vyrnwy reservoir of the Liverpool Corporation Waterworks, designed by and partially carried out under the direction of the late Mr. Thomas Hawksley, after whose retirement it was completed by Mr. G. F. Deacon, who presided over Section G on the occasion of the visit of the British Association to Toronto in 1897; and again at the reservoirs near Rhayader, in Wales, now approaching completion, from the designs and under the direction of Mr. James Mansergh, F.R.S., Past President Inst.C.E., for the supply of water to the city of Birmingham.

From the impounding reservoir the water has to be conveyed to the point of distribution by an aqueduct. This aqueduct, which is sometimes of great length, may consist either wholly of metal pipes, usually of cast iron, or partly of a conduit constructed of masonry, brickwork or concrete following the contour of the ground, with occasional tunnels where high ground has to be passed through, and metal (inverted syphon) pipes where valleys have to be crossed. These conduits may be either open or covered, the latter method being generally adopted, when they become what is technically known as 'cut and cover' conduits. In the case of a continuous pipe-line of considerable length it is divided into sections by means of break-pressure tanks interposed at suitable elevations, each tank being say 100 feet or thereabouts below the preceding tank, by which means the pipes are relieved from the excessive pressure to which they would be subjected if the head due to the elevation of the impounding reservoir was carried forward to the service reservoir, from which the water is distributed to the consumer. Steel pipes are frequently used abroad where the cost of carriage is great, but they have not yet been much employed in this country, sufficient experience not having yet been gained in reference to the deterioration of steel pipes due to the action of the water from within and of the ground in which they are laid from without.

The lines of pipe are provided at intervals with suitable stopcocks, sluice-valves, and air-valves, and also in some cases with self-acting valves which close automatically in the event of the velocity of the water in the pipe becoming abnormally increased owing to the bursting of a pipe beyond.

I have already stated that most waters obtained from gathering grounds are much improved by filtration. The process of filtration may be carried on where the water leaves the impounding reservoir or at any convenient point on the line of conduit thence to the place of distribution, provided the filter-beds are situate at such an elevation as to place them on the line of hydraulic gradient. Various considerations will influence the determination of their position, but it is desirable that the water should not be subjected to long exposure to light after filtration. Filtration by the slow passage of the water through a bed of sand from two to three feet in thickness, supported by small gravel or other suitable material, is the method usually adopted in Europe, though what is known as mechanical filtration has been used to a considerable extent in the United States, and may under certain conditions be usefully employed. However I do not think it is likely to take the place to any considerable extent in this country of the efficient system of sand-filtration introduced so long ago as the year 1828 by the late Mr. James

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Simpson, Past-President of the Institution of Civil Engineers. The rate of filtration, to be thoroughly effective, must depend on the condition of the water to be filtered, but a rate of from 450 to 550 gallons per square yard of surface of sand per day (*i.e.*, twenty-four hours) is usually found to be efficient. Filter-beds are generally open to the sky, but occasionally, when situate at considerable elevations, they are covered by roofs to prevent interruption by the formation of ice in times of severe frost. In certain exceptional cases in which the water is difficult to treat it is twice filtered with excellent results. The water after filtration should be discharged into a pure-water tank or service reservoir of sufficient capacity to enable the process of filtration to proceed at a uniform rate by night as well as by day, without regard to irregularities in the rate of demand in the district of supply.

The particles in suspension in the water, which are intercepted by the process of filtration, gradually form a film over the surface of the sand, and thus improves the filtration; but this film at last becomes so thick as to unduly reduce the rate at which the water passes through the sand. The filter-bed is then laid off and, the water having been withdrawn, the surface of the sand is scraped off to a depth of about a quarter of an inch; the sand thus removed is washed in suitable machines to free it from the matter intercepted during the process of filtration, and is afterwards replaced in the filter-bed either immediately or after several similar scrapings have taken place, care being taken that the thickness of the sand left in the bed shall not at any time be reduced below that required to ensure efficient filtration. From time to time the sand is removed to a depth of several inches and washed, and occasionally it is taken out and washed to its full depth. From the foregoing description it will be understood that the filtration of water, although a simple process, is one which necessitates constant watchfulness on the part of those responsible for the management of those waterworks undertakings in which the water undergoes filtration.

As near to the termination of the aqueduct conveying the water from the impounding reservoir to the point of distribution as the levels of the ground will permit, a service reservoir should be constructed for the purpose of equalising the flow of water along the aqueduct, and for maintaining the supply to the district during any temporary interruption on the line of aqueduct due to a burst pipe or otherwise. The service reservoir should contain not less than one day's supply, two or three days, and, in exceptional cases, even more being sometimes desirable. Service reservoirs should by preference be covered so as to exclude light, and thus prevent the growth of vegetation which would otherwise take place. The covering, when consisting of brick arches, has also the advantage of keeping the water cool in summer, and preventing the temperature from becoming too much reduced in winter. The rate of draught on the service reservoir is continually varying throughout the day and night according to the hourly requirements of the population which it serves. This variation is very considerable, amounting during certain hours of the day to at least twice the average rate of consumption during the twenty-four hours. It will therefore be apparent that were it not for the equalising effect of the service reservoir the aqueduct must have a capacity at least double that which is needful where a service reservoir is available. At Southport, for example, although the water is distributed from a service reservoir, that reservoir is situate at a distance of about seven miles from the town, because, owing to the great extent of comparatively flat land in the neighbourhood of Southport, it was impossible to obtain a suitable elevation nearer to the town than Gorse Hill, on the summit of which the reservoir stands. Consequently the main pipes thence to the town have to be of sufficient capacity to convey the water at a rate corresponding with the demand at the time of *maximum* consumption, or, in other words, of about twice the capacity which would have been needed if the service reservoir could have been placed close to the town, when these pipes would, for the greater part of their length, have been situate on the inlet instead of on the outlet side of the reservoir.

Having now followed the water in the case of a gravitation supply from its source to the service reservoir from which it is to be distributed to the consumers, it will be convenient to follow in a similar manner water obtained by means of

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pumping, leaving until later the consideration of its distribution, which, after it leaves the service reservoir, is common to both gravitation and pumped water.

Pumping supplies may be divided into two sections—first, those where the water is drawn from a source only slightly below the level of the pumping engines, such as where the water is taken from a stream or lake, or from culverts formed in gravel beds, or is discharged from impounding reservoirs situate at too low a level to enable the water to gravitate to the point of distribution; and secondly, where the water is raised from deep wells sunk in the sandstone, chalk, or other water-bearing strata.

In the first-mentioned cases the water has usually to be filtered, when it is generally found convenient to place the filter-beds at the pumping station, the water being firstly lifted (unless it will gravitate) on to the filter-beds, and secondly, after filtration, and by means of a separate pump, forced through pipes up to the service reservoir whence it is to be distributed.

In the case of deep wells, the water seldom, if ever, requires filtration, and is usually raised either directly or through pipes into the service reservoir, the total lift being frequently divided between lift pumps and force pumps with the object of balancing the work to be done by the engine.

Sometimes the well alone will yield a sufficient supply of water, but often it has to be aided by boreholes or by drifts or headings driven horizontally in the water-bearing strata near the level of the bottom of the well, and occasionally continued for a considerable distance, even as much as a mile or more from the well, the length of the headings depending on the quantity of water which can be profitably obtained from them, and also on other considerations too various to be mentioned here. There are cases in which it is possible to obtain sufficient water by boring from the surface of the ground and lowering a pump down the borehole. The expense of a large well is thus saved, but it is, of course, impossible to augment the supply by drifting.

The time at my disposal will not admit of any observations on the merits of the various kinds of engines and pumps employed in raising water; they are not only very numerous, but each has to be considered in relation to its suitability for the particular circumstances of the case in question. Suffice it to say that, although most of the water pumped in the United Kingdom is raised by means of steam engines, water turbines, gas engines, oil engines, and (to some slight extent) electric motors are also employed. It may be mentioned that one of the largest oil engines in this country is engaged in pumping water from a deep well, and it is not improbable that gas and oil engines will in the future become more largely employed for waterworks purposes.

It should here be mentioned that there are a few instances in this country, and many in the United States of America, in which a service reservoir is dispensed with, and water is pumped directly into the main and distributing pipes of the district to be served, a method which, although employed with success, should not, in my opinion, be adopted where the circumstances admit of the use of a service reservoir. Where direct pumping is used, provision must be made to ensure continuous pumping day and night without intermission, so as to avoid interruption to the supply of the district, and the speed of the engines must be constantly varied to meet the demands of the consumers for the moment. The maintenance of uniformity of pressure in the main pipes may be assisted by the employment of large air vessels, or by accumulators such as are used for the supply of hydraulic pressure, or preferably by a combination of air vessels and accumulators.

We will now return to the service reservoir. When this reservoir is situate between the source of supply and the district to be supplied, it receives the whole of the water and delivers it into the district as needed for use; but when the district lies between the source and the service reservoir, it receives the excess of supply over consumption, and on the other hand makes good any deficiency during those hours when the consumption exceeds the supply. In either case this reservoir has the effect of equalising the flow from the source to the reservoir throughout the twenty-four hours of the day.

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From the service reservoir the water is conveyed by one or more main pipes into the district of supply. These pipes are gradually reduced in diameter as they pass through the district, the water which they convey is taken off by other main pipes branching from them, and finally enters the service pipes, which are usually from five inches to three inches diameter, and are those from which the consumers' communication pipes are taken. The service pipes should in all cases be controlled by valves, so that the water can be shut off from them without interfering with the flow through the main pipes. Consumers' communication pipes are not generally allowed to be attached to pipes of greater diameter than five inches, and where a pipe of six inches diameter and upwards is carried along a street, another pipe of three or four inches diameter (preferably the latter size) and called a ryder pipe, is laid alongside to receive the attachments of the communication pipes. The ryder pipe is divided into lengths of from 350 to 400 yards, each of which is controlled by a valve at its junction with the main pipe. Hydrants for use in case of fire are attached to the ryder and other service pipes throughout the district at a distance apart not exceeding 100 yards. Except in streets where the houses are small and not high, it is desirable to lay the service pipes of not less than four inches diameter, not because a smaller pipe would not suffice to meet the requirements of the domestic consumers, but in order to ensure an ample supply of water in case of fire. When determining the sizes of the main pipes to be laid throughout a town, the engineer commences with the pipes most remote from the service reservoir, and gradually increases the diameter according to the probable number and magnitude of the supplies to be taken from them.

Pipes of cast iron having sockets run with lead and set up with a hammer are mostly used for waterworks purposes, but in some instances turned and bored joints put together without lead have been used with success, but these are only suitable where there is an unyielding foundation. I remember a case in Yorkshire, where turned and bored pipes were, much against the advice of the engineer, used for the distribution of gas in a colliery district, with the result that in a few years nearly every joint was leaking; fortunately the engineer had anticipated this result, and had laid the pipes with sockets in addition to the turned and bored joints; consequently, by opening the ground at each joint and running the joint with lead, the leakage was stopped without necessitating the relaying of the system of pipes. The main pipe of forty-four inches diameter, conveying water from Rivington to Liverpool, passes for several miles over a coalfield, and the ground has in places subsided over the coal workings as much as four feet without interfering with the supply of water; the ground having been opened at the pipe joints, the lead, which had been partially drawn from the joints, was forced back by hammering, and the joint was again made sound.

In some countries, where the cold is intense, water pipes have to be laid at a depth of from 10 feet to 12 feet below the surface of the ground to protect the water from frost, but in the United Kingdom a depth of from 2 feet 6 inches to 3 feet has been found to be sufficient even in very severe frosts.

Water, especially when soft, causes the interior of cast-iron pipes to become incrusted with nodules of iron, which reduce the effective diameter of the pipe and so diminish its capacity. This action is greatly retarded and in some instances entirely prevented by the application to the pipes, soon after they have been cast, of the coating introduced many years ago by the late Dr. Angus Smith, a process now nearly always employed.

It was at Southport that I witnessed the bursting of a main pipe, the only occurrence of the kind that I have seen during a period of forty years, of which a considerable portion has been spent amongst waterworks. Owing to the introduction of a new supply of water, the original main pipe was charged with water at a higher pressure than it had been intended to bear, with the result that several fractures occurred. I happened to be standing on one of the roads at a little distance from the town when I heard a sound, and looking in the direction whence it came, saw in a field near by a black column rise vertically in the air for about forty feet in height. A girl who happened to be working in the field put her

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hands to her ears and fled, probably thinking she had seen Satan himself, but the column soon became clear, the black colour having been caused by the peat carried up with the water.

Having traced the water from its source to the door of the consumer, we now enter into another branch of the subject. Up to this point the water has been entirely under the control of the company or local authority by whom it is provided, but from the moment it enters the consumer's communication pipe, or where the communication pipe is the property of the water supplier, from the moment the water reaches the premises of the consumer, it comes under his control, subject only to such regulations and surpervision as the Legislature has given the water supplier power to make and to exercise.

When water was supplied on the now almost obsolete 'intermittent service,' under which a town was divided into a number of districts into each of which in succession the water was turned for only one or two hours a day, the water suppliers paid but little attention to the fittings within the houses of the consumers, because, however great the quantity of water wasted through defective fittings, the waste could only last for the short time during which the water was turned on in each district, and it ceased altogether during the night.

About the year 1831 the system of 'constant service,' by which is meant a supply of water available from the pipes of the water suppliers at any moment throughout the day or night, was introduced into this country by the late Mr. Thomas Hawksley, at Nottingham, and it soon became evident that if a constant service was to be maintained the fittings within the houses of the consumers must be adapted to the new conditions and be placed under regulation and supervision. Suitable regulations were therefore formulated, and have since been improved and modified to meet modern requirements. These regulations, which are mainly directed to the use of proper pipes, taps and other fittings, and to service cisterns so constructed as to prevent a continuous flow and consequent waste of water, do not in any way limit the use of water by a consumer, who is at liberty to take as much as he requires whether by day or by night, nor does their strict enforcement inflict any hardship on the consumer, to whom good water fittings kept in a proper state of repair are in the end more economical than cheaper and inferior fittings requiring the frequent attendance of the plumber.

About five years ago, I had occasion to obtain statistics relating to the consumption of water in sixteen towns (including Southport) in England, containing an aggregate population within the district supplied of rather over five millions of people, and found that the average quantity of water consumed in those towns for domestic purposes was 18½ gallons per head per diem, showing what can be effected by good management and a careful observance of proper regulations for the prevention of waste without imposing any restriction on the quantity of water legitimately used. The figures which I have quoted as water for domestic purposes include the unmetered trade supplies and that comparatively small amount of waste which cannot be prevented, but do not include the water supplied by meter for trade purposes, the amount of which varies greatly in different towns, but being paid for by the consumer according to the quantity used may be disregarded when comparing the management of waterworks undertakings.

Some soft waters, more especially those derived from moorlands, have an injurious action on lead pipes and lead-lined cisterns, and are liable to cause lead poisoning in sensitive persons drinking the water, but this action is now commonly prevented by bringing the water into contact with lime before distribution.

In certain instances of public supplies, the hardness of the water is reduced by one of the several softening processes now in use, but it more frequently happens that the softening is effected by those consumers who require soft water for boiler or other trade purposes.

A few words with regard to the water supply of the town in which the Meeting of the British Association is now being held may not be out of place, the more especially when it is borne in mind that the rapid growth of its population during the last half century could not have taken place but for the introduction of a supply of good water.

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The Southport Waterworks Company, by whom water was originally brought to Southport, was established under the authority of an Act of Parliament passed in the year 1854. Water was first obtained from a well sunk at Scarisbrick, about five miles south-east of Southport, a source which was practically superseded by another well which was a few years later sunk at the Aughton pumping station near Ormskirk. As the population to be supplied increased in number, the Company subsequently sunk a third well, and constructed the still larger Springfield pumping station near Town Green, about nine miles south-east of Southport, and it is from the Aughton and Springfield wells, both sunk into the Bunter Beds of the New Red Sandstone formation, that the present excellent supply of water is derived. At each pumping station the water is raised by a pair of beam rotative steam-engines into two covered service reservoirs situate on the summit of Gorse Hill, near Ormskirk, at an elevation of 260 feet above ordnance datum, or in other words, above the mean level of the sea. From this reservoir the water is brought through two main pipes to Southport and Birkdale, which places have from the commencement of the undertaking had the advantage of a constant service. The late Mr. Thomas Hawksley acted as engineer to the company from its formation until his death in 1893, and I subsequently acted in that capacity until the transfer, under the powers of the Southport Water (Transfer) Act, 1901, of the undertaking of the company to the Southport, Birkdale, and West Lancashire Water Board, consisting of representatives of the Corporation of Southport, the Urban District Council of Birkdale, and the Rural District Council of West Lancashire.

The advances in recent years in chemical science, and the application of the science of bacteriology to the examination of water, have led to the condemnation of waters which a few years ago would have been deemed to be perfectly suitable for a town supply. Whilst fully appreciating the advantages to be derived from the most careful examination of water supplied for domestic consumption, I cannot but think that we are sometimes unnecessarily alarmed by the results obtained. Taking a broad view of the subject, and looking to the healthy condition of towns which have for many years been supplied with water from sources now regarded with suspicion, I venture to think that the teachings of chemistry and bacteriology are as yet but imperfectly understood, and that in the future it will be found that some waters now considered of doubtful character are perfectly good and wholesome. I am well aware that the expression of these views may call forth the indignation of some of my friends amongst eminent chemists and bacteriologists to whose opinions on such subjects I feel bound to pay deference. A Royal Commission has recently recommended that a Government department be established and endowed with enormous powers of interference with the action and discretion of the bodies entrusted by Parliament with the responsibility of the administration of water supplies, and it behoves those bodies to give careful consideration to this recommendation, and to take such steps as may be necessary to check any attempt to give effect to a proposal which may result in committing them to the carrying out of unreasonable requirements, possibly involving needless expenditure, at the bidding of a Department from whose dictum they may have no appeal.

Although a matter only indirectly connected with water supply, I think it may be of scientific interest to this Section to have brought to their notice the case of the River Rede in Northumberland, which takes its rise in the Cheviots. At a place called Catcleugh, about four miles below the source of the Rede, its waters are diverted by the Newcastle and Gateshead Water Company for the supply of their district. The gathering-ground above the point of diversion is about 10,000 acres in extent, and the quantity of water taken is ascertained by means of a gauge, and registered continuously by a recording instrument. An inspection of the diagrams taken during periods in which there was no rainfall shows a daily variation in the volume of water flowing down the river. For example, during a period of eight days (June 9 to 16, 1899) without interruption by rain, the gradual rise and fall of the river was almost regular, day by day, the maximum flow occurring about 9 A.M., and the minimum about 9 P.M., the difference between the two amounting to nearly 10 per cent. of the total quantity passing down the river

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at the time of minimum flow. Various suggestions as to the cause of this phenomenon have been made, but I am unable to give any satisfactory explanation. It occurs in winter as well as in summer, and may take place daily throughout the year, though it cannot be observed except during dry periods. It may well be that a similar phenomenon occurs in other rivers, but has escaped observation owing to the absence of recording gauges.

The following Papers were read:—

1. *King Edward VII. Bridge over the River Thames between Brentford and Kew.* *By* CUTHBERT A. BRERETON, *M.Inst.C.E.*

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2. *Illustrations of Graphical Analysis.* *By* J. HARRISON.

FRIDAY, SEPTEMBER 11.

The following Papers and Report were read:—

1. *The Equipment of the Manchester Municipal Technical Institute.* *By* J. H. REYNOLDS.

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2. *Report of the Committee on the Resistance of Road Vehicles to Traction.*—See Reports, p. 365.

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3. *Improvements in Locomobile Design.* *By* T. CLARKSON, *Assoc.M.Inst.C.E.*

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4. *The Problem of Modern Street Traffic.* *By* Lieut.-Col. CROMPTON, *C.B.*

The author points out that this is the question of the day, that the roadways in large cities are increasingly congested in spite of relief being given by shallow and deep underground railways, by great extensions of tramways, and by much costly widening and straightening of winding streets. Heroic proposals are made to cut wide thoroughfares through London—in fact to Haussmannise London. A Royal Commission is sitting to investigate the whole question of the communications of London.

The paper does not discuss these larger schemes, but draws attention to the great extent by which traffic regulation would ameliorate matters.

The author suggests the formation in every large town of a traffic department, possibly under the control of the head of the police. This traffic department should be empowered to make rules for regulation of traffic and for diverting the heavy traffic out of main thoroughfares into side streets; and would be the expert authority to deal with all traffic, rail and trade, proposals coming before Parliament or the county councils.

Chief cause of the congestion of traffic is the mixed nature and varying speeds at which it is carried. Fast and slow traffic ought to proceed in different streets.

The proposed traffic department would, in the case of London, require increased powers being given to the police; hence the careful consideration and sanction of Parliament; and this will take time. Some of our large towns have already obtained in their private Bills considerable powers for dealing with street

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traffic. Nottingham, for instance, has taken up the matter of regulating the heavy traffic. It is believed that the present paper may be of use to those dealing with traffic matters.

In ideal conditions of traffic the lines of vehicles are all parallel to the kerb and under favourable conditions, with vehicles of approximately the same speed the streets have an enormously increased capacity. The extent of this is shown by a table in which the ordinary London omnibus is taken as a typical vehicle. The table shows the number of passengers that can be carried by fully loaded omnibuses past a given point per hour at various speeds and with various intervals between the omnibuses. This table is prepared from the following formulæ:—

Where V is the speed of the omnibuses in miles per hour.
D the interval between the omnibuses in feet.
S the time-interval in seconds.
N the number of passengers.

Then

$$N = 137{,}280\ V/D$$

and

$$S = D/V. \cdot 681$$

A very useful regulation would be one dealing with stopping vehicles, defining in certain thoroughfares the time which vehicles may be allowed to stop. It is suggested that a great many goods which are required for the regular supply of a neighbourhood may be delivered between certain hours, other than those when traffic is usually most congested.

Great relief would be given to traffic by the removal of stopping vehicles altogether from the streets. This could be effected by some modification of the court and *porte-cochère* system so largely used in continental cities. In this case many offices or places of business could open into one court into which visiting vehicles would draw out of the public thoroughfare.

A much larger proportion of the message and business visiting of our large towns could be carried on bicycles (which is probably the vehicle most economical of space of those which use the roadway) if facilities could be given for storing them near the places of business. This could be arranged in the proposed courts. Motor vehicles also could be stored in sub-basements by the use of lifts, and in this way a considerable proportion of the vehicles bringing passengers into the business quarter in the morning could be stored there all day and thus avoid the necessity of a daily double empty journey.

Relief can also be given to traffic by regulations as to returning empty carriages. These, in many cases, need not return by the most direct and busiest routes.

The author points out that one great cause of congestion is due to cross traffic carried on the same level. Sir John Wolfe Barry has suggested bridging our main thoroughfares and carrying cross traffic over or under them. The successful widening experiment at Hyde Park Corner has shown, however, that if considerable widening is carried out at crossings—in fact, if something like Regent and Oxford Circus were introduced at each important crossing—great relief would be given to traffic.

The widening of both the main street and the cross street for a certain distance on each side of the crossing is probably the most economical and efficient way of increasing the capacity of a street for any given expenditure of money.

Next comes the speed question. Most of the attempts to deal with modern traffic have been unsuccessful in decreasing the time required to get from one part of the town to another. Electric tramways, from which much was hoped, practically do not exceed the old omnibus speed of seven miles an hour. A good deal is to be hoped from automobiles, especially electric automobiles. These vehicles can be run through traffic at 50 per cent. greater speed than horse-drawn vehicles. It is to be noticed that speed is desirable as for a given amount of traffic the number of vehicles required to carry it is inversely proportional to the

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speed. It is desirable that the mean speed should closely approach the maximum speed. This can only be obtained by using very considerable power, so as to give a great rate of acceleration. Rapid rate of acceleration and great brake-power is all important in facilitating traffic.

Most towns have their older and more important streets arranged radiating from the original centre, market-place or otherwise. This tends to extra congestion near the centre of the town, but it can be relieved by concentric circular roads or boulevards, so that traffic crossing a large town can enter by one radial road, pass the centre by one of these circular roads, then take a radial out again. These concentric roads are much wanted in all towns. Regulation of foot-passengers is as necessary as that of vehicles. Wide footways are needed, but much can be done by passengers always keeping to the right, whether in the footway or roadway.

MONDAY, SEPTEMBER 14.

The following Papers and Report were read :—

1. *The Nature and Quality of some Potable Waters in South-west Lancashire.* *By* Professor J. CAMPBELL BROWN.

2. *Protective Devices for High-tension Electrical Systems.* *By* W. B. WOODHOUSE, *A.M.I.M.E.*, *A.M.I.E.E.*

The extending use of high tension polyphase transmission is resulting in a gradual standardisation of the methods adopted to protect such systems against breakdown; but there is still some considerable diversity of opinion shown. The writer proposes to discuss several points in connection with the operation of a high tension polyphase transmission system.

Nature of System.

The design of the system should be such that each part is automatically disconnected in the event of a breakdown of that part; the continuity of supply being of primary importance, all parts should be duplicated.

Stresses on the System.

In switching on an unloaded cable a wave of pressure passes along the cable and is reflected; there may be a rise of pressure to twice the working value.

In switching on a transformer or an induction motor, or any apparatus with considerable inductance, the full pressure exists for the moment between adjacent coils, the greatest stress falling on the end coils. An inductive circuit has stored energy to the amount of $\frac{I^2L}{2}$ joules, which must be dissipated when the circuit is broken. In a transmission system such as is considered, this energy may be converted to the electrostatic form on opening circuit with a resultant rise of pressure; neglecting damping effects the pressure may rise to a value $E = I\sqrt{\frac{L}{C}}$ or the rise of pressure is proportional to the current flowing at the moment of interruption. Pressure rise from resonance is not likely to occur in commercial systems in this country.

The interval of time between the occurrence of an overload and the opening of the circuit should be inversely proportional to the magnitude of the overload; that is to say, on a moderate overload there should be a time-lag of some seconds.

A little consideration will show that all circuit-breakers on a system should be capable of breaking the whole power which can flow into that part of the system.

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Protective Devices may be divided into two classes:

(1) Circuit breakers.
(2) Devices which prevent or relieve excessive rises of pressure.

Class 1 may be again divided into two subdivisions: (*a*) Fuses; (*b*) Switches.

The action of two types of fuses is discussed and curves given showing the difference between the two types.

The oil-break switch is found to be the only workable type for large powers, and the details of operation of such switches are gone into.

The automatic attachments for opening the switch on overloads and reversals of power are described.

Class 2 includes charging devices, which the author considers unnecessary, and spark-gaps of which a new type of oil immersed spark-gap is described, which, the author considers, will safeguard a system from undue pressure-rise.

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3. *Aluminium as an Electrical Conductor.* *By* J. B. C. KERSHAW, *F.I.C.*

The increasing use of aluminium as an electrical conductor for bare overhead transmission lines, especially in the United States, and the claims made for this metal as a substitute for copper, led the author in October 1899 to commence a series of exposure tests at two localities in Lancashire, England.

These tests were made in order to ascertain the resistance to corrosion offered by *commercial aluminium rod and wire under the conditions obtaining*, with exposed bare overhead wires. Samples of aluminium rod and wire were obtained from the principal English firms, and in order to make the series of observations more complete, samples of galvanised iron wire and of copper and tinned copper wire were also submitted to atmospheric exposure. The methods of observation and the results obtained during the first exposure period (from October 1899 to August 1900) were described by the author in a paper read before the London Institution of Electrical Engineers on January 10, 1901. This paper was reported in most of the English and foreign technical journals.

The present paper is the record of the observations made since the date named above, and it contains the chemical and physical tests of the aluminium wires exposed at Waterloo, Lancashire, together with the results obtained during two further periods of exposure, namely, from August 22, 1900, to November 6, 1901, and from November 9, 1901, to December 4, 1902.

Since it may be considered unnecessary to repeat much of the information contained in the Electrical Engineers' paper of January 1901 the author proposes to treat the present paper as a continuation of that of 1901, and to simply bring the tables and information of the earlier paper up to date.

The author then deals seriatim with the following points: (1) Production and price; (2) Relative costs of copper and aluminium; (3) Installations of aluminium for conducting purposes; (4) Durability tests of aluminium and other metals under atmospheric exposures; and concludes his paper with the following summary of the results obtained in the exposure tests at Waterloo:

'Summarising the results recorded in Table II., we may say that all the samples of aluminium gained in weight during exposure, and that *all* were pitted and corroded, especially on the under side where the water drops had collected and dried. The rods appeared to have suffered rather less than the wires, and it is therefore probable that in the course of drawing down, aluminium wire undergoes physical change.

'The author does not wish to base any unfair conclusions upon the results obtained in these exposure tests. He may, however, claim to have proved that some of the aluminium rod and wire which was being manufactured and sold in England for electrical purposes in the years 1899 and 1901, was not able to stand atmospheric exposure on the coast of Lancashire without corrosion. It is only a fair deduction from these exposure tests to assert that aluminium manu-

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facturers have yet to prove the metal a satisfactory and durable substitute for copper in bare overhead transmission lines, or for electrical *work which involves exposure to climates near the sea coast.*'

Three tables accompany the paper, the first showing the output and average price of aluminium annually for the period 1890–1902; the second giving details of the exposure tests at Waterloo; and the third containing chemical and physical tests of the aluminium wires used in the author's experiments.

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4. *The Electrical Conductivity of certain Aluminium Alloys as affected by exposure to London Atmosphere.* *By* ERNEST WILSON.

This paper gives the results of a second year's exposure of twenty-four alloys in the form of wire ·126 inch (3·2 mm.) in diameter. The first year's exposure-tests were described at the Belfast meeting in 1902. It was then shown that if aluminium be alloyed with copper in varying proportions (·11 to 2·61 per cent.) the effect of exposure was to increase electrical resistance to a greater extent the greater the percentage of copper. During the second year's exposure this process has progressed still further, *but to a less extent.* The aluminium appears to cover itself with a protecting film. The manganese alloys are interesting in that they have not increased electrical resistance during the second year's exposure. The nickel series have also changed very little during the second year's exposure. On the other hand, the nickel-copper alloys, which showed no increase of electrical resistance during the first year's exposure, have changed during the second year's exposure. For exposed light aluminium alloys, the results confirm the conclusion arrived at in the 1902 paper, that copper alone should not be used in comparatively large quantities.

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5. *A Method for finding the Efficiency of Series Motors.* *By* ERNEST WILSON.

This paper describes a method of finding the efficiency of series motors which the author has found to work well in practice, and which is capable of giving great accuracy. The armatures of two like machines are mechanically coupled together, either through or without gearing, according as it is desired to obtain the efficiency of either machine inclusive or exclusive of its gearing. In the test one machine runs as a motor and delivers its energy to the other, which runs as a generator, loaded on an external resistance. The two field-coils and the motor armature are placed in series across the supply mains, and thus the machines are conveniently magnetised to the same degree. It is usual in such tests to measure the input of the motor and the output of the generator as direct quantities, the difference giving the energy dissipated in the system. The losses due to electric current in the respective ohmic resistances can then be subtracted from such difference, and the remainder, due to eddy currents, magnetic hysteresis, brush, bearing, and wind friction, can be found. Instead of measuring the volts and amperes at the motor and generator terminals respectively, the author measures (1) the volts at the motor terminals, and the difference between these and the volts at the generator terminals; (2) the amperes delivered to the motor, and the difference between these and the amperes in the generator armature circuit. For the latter purpose he employs two low-resistance shunts, one placed in each circuit, and a millivoltmeter so connected that it reads the difference of potential difference due to the two currents in the respective low-resistance shunts. The wires connecting these shunts pool the like poles of the machines together, so that a voltmeter placed between their other poles reads the difference of potential difference of the machines. The author then gives a numerical example to show that the accuracy obtainable is much greater when this differential method is employed, than by the first described method.

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6. *Parallel Working of Alternators.*[1] *By* B. HOPKINSON.

The hunting of alternating-current machines is considered as a case of oscillation about a state of steady motion. The oscillations may be forced oscillations, produced by uneven turning moment in the engines, or free oscillations, such as are set up on switching a machine into parallel when slightly out of phase. The importance of the forced oscillations depends largely on the relation between the period of the cause producing them and the period of the free oscillations. Let ξ'_0 be the maximum angular phase-displacement of a dynamo driven by a periodically uneven turning force as compared with a wheel rotating uniformly at the same speed, the dynamo being disconnected from the bus-bars. Let $\frac{2\pi}{\delta'}$ be the period of the variation in turning moment, $\frac{2\pi}{\delta}$ the natural period of swing of the dynamo. Then the maximum phase-displacement when the dynamo is connected to bus-bars supplied with alternating E.M.F. of constant amplitude and periodicity is

$$\xi_0 = \xi'_0 \Big/ \left(\frac{\delta^2}{\delta'^2} - 1\right)$$

The usual rule as regards flywheel effect is that ξ'_0 shall not exceed a certain value, varying for different designs. This is equivalent to limiting ξ_0 provided that δ is small compared with δ', or that the natural period of swing is long compared with the forced period. With the weight of flywheel required to satisfy the ordinary rules of design for proper parallel working, this condition is generally fulfilled. These rules, therefore, as a rule, directly limit the phase angle of swing in ordinary working. What is wanted, however, is limitation, not of the angle, but rather of the fluctuation in the rate at which energy is given to the bus-bars to which that angle corresponds. This depends on the self-induction of the machine. Hence the very considerable differences in the angular deviation permitted by different designers; a machine with large self-induction will stand a bigger angular deviation than will one with small self-induction.

Similar considerations apply to a synchronous motor or a converter connected to mains in which there is a periodical fluctuation of E.M.F., owing to uneven velocity in the supply generators. In this case, however, as it is unusual to put any flywheel on the motor, the danger of approximate equality between δ and δ' is much greater. Probably many cases of hunting of rotaries might be better and more cheaply cured by putting flywheels on the rotaries than by excessive requirements as to even turning moment in the generator.

The importance of the free oscillations depends on whether they are damped out or not. The equation of motion is

$$\mathrm{M}\frac{d^2\xi}{dt^2} + b\frac{d\xi}{dt} + c\xi = 0$$

ξ being the phase displacement from the state of steady motion, and M the moment of inertia of the machine on a suitable scale. The solution of this equation is

$$\xi = \xi_0 e^{-\frac{b}{2\mathrm{M}}} \sin(\delta t + \eta).$$

where $\delta = \sqrt{\frac{c}{\mathrm{M}}}$ if b is small, and $\frac{2\pi}{\delta}$ is the period of the oscillation. Most oscillating systems possess viscosity, in which case b is positive, and the oscillations

[1] Published *in extenso* in the *Electrician*, September 18, 1903.

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rapidly die away if once started. If however b be negative, even though very small, the oscillations continually increase in amplitude, and the motion is unstable. In the case of a synchronous motor, having its field-magnets, armature conductors, and armature so perfectly laminated that no appreciable Foucault currents flow therein, and in which the field current is kept constant, b is negative, and the motion is unstable. In most actual cases, however, this element in b is very small, and is in practice overpowered by true viscous terms, such as arise from Foucault currents in the armature conductors and in the substance of the pole-pieces. Where motors or converters are used on long transmission lines, however, it may become important, and the motion may be unstable from this cause, giving rise to serious hunting, even with turbine-driven generators.

The effect of damping coils or amortisseurs on the free oscillations is considered and explained. In the case of coils surrounding the pole-pieces, the induced currents set up by the varying armature reaction add a term to b whose sign depends on the load. At light loads it may be negative, and in that case these coils may act as additional causes of unstability. This effect, also, is of comparatively small importance in ordinary cases, but may become important in motors on long transmission lines.

The other kind of damping coils, consisting of copper grids let into the face of the pole-pieces, always give rise to true viscous forces, and consequently tend to make the motion stable. Moreover, their effect is much more powerful than is that of coils surrounding the pole-pieces, and by their use it is generally possible to make b positive.

The effect of damping coils on the forced oscillations can be inferred from the observed rate of damping of the free oscillations, and is generally insignificant.

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7. *On Electrical Propulsion as the General Means of Transport.*

By JAMES N. SHOOLBRED, *B.A., M.Inst.C.E.*

The tendency of the last few years has been, in England and elsewhere, to introduce electric-tractive power—on tramways, on railways, on road-carriages, on canals, in automobiles, and in other ways. But these various groups have each been acting independently of the others—isolated, and in some cases actuated, thereto, by motives of jealousy, or of hostility, due to the dread of conflicting commercial interests.

Besides the above proposed applications for electrical traction, there have sprung up in various directions what may be termed 'universal providers of electricity,' under the head of electrical power schemes, &c.; to acquire a right, nay, even a practical monopoly, over very large areas, to provide a supply of electricity for, within certain limits, all purposes, whether for locomotion, or for stationary purposes.

It is only reasonable to suppose that, if instead of a number of conflicting interests, the various parties could be made to combine and fuse together the several portions of their common work, so as to avoid a repetition, and antagonistic, in some cases, of some portions thereof, there might then arise mutual benefit, as well as economy, not merely to the operators themselves, but also to the community at large. One difficulty lies in the conflicting interests and in the jealousy amongst the various classes of operators. But another danger to the public, more especially, lies in the monopoly which virtually might thereby be afforded to the operators.

An attempt has been recently made by the Liverpool Corporation, the Mersey Docks and Harbour Board, and the South Lancashire Electric Tramways to give expression to this tendency for co-operation among the various workers; and there are indications in Yorkshire and elsewhere of similar tendencies coming into operation.

Although the result, so far, of the attempt above referred to has been rather to accentuate than otherwise the difficulties which beset a united undertaking of such a character, yet the benefits which would ultimately accrue to the public

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(say in cheapening the cost of transportation by a more comprehensive and united action among the workers) fully warrants their being discussed.

In the paper particulars are proposed as would tend to such a joint action, and to the benefits arising therefrom.

8. *Report of the Committee on the Small Screw Gauge.*
See Reports, p. 378.

TUESDAY, SEPTEMBER 15.

The following Papers were read:—

1. *Twenty-five Years' Progress in Final and Sanitary Refuse Disposal.* *By* W. F. GOODRICH.

2. *High Speed Electrical Monorails and the proposed Manchester and Liverpool Express Railway.* *By* F. B. BEHR.

Since a paper on the above subject was read before the British Association in 1900 by Sir William Preece and Mr. Behr, much progress has been made with this project. The demand for faster and more frequent passenger service is leading more and more to the necessity of separating the fast and slow traffic on our railways. The railway companies are attempting in some instances to duplicate their main lines, but owing to the inter-communication which is still maintained between the fast and the slow lines, there are many opportunities for accidents due to shunting, points, crossings, etc.

By adopting the Behr monorail for the fast line, the express traffic is kept entirely separate; it can also be carried on with absolute safety and more economy by a system of light and frequent express trains than could be accomplished on a two-rail track. As regards speed the monorail enables a much higher average speed of, say, at least 100 miles an hour to be adopted with absolute safety, and on the existing curves of our British railways. With an ordinary two-rail track it would not be possible to attain a higher average speed than about sixty miles an hour.

The constant slackening of speed on entering, and the subsequent acceleration on leaving a curve on a two-rail track would require much additional power, besides introducing the danger of derailment through forgetfulness on the part of the driver or electrician to slow down when necessary. The monorail eliminates these conditions.

A description illustrated by lantern-slides was given of the permanent-way and car as used on the experimental railway in Belgium in 1897, also of the permanent-way as approved by the Board of Trade for the Manchester and Liverpool Railway, and of the latest improvements, recently made, in the design of the car which is to be used on the railway.

The advantages of the monorail over the ordinary two-rail track, in giving rapid and safe transit, will help effectually to bring about the decentralisation of our great towns, afford a means to all classes of living farther in the country, and thus mitigate the evils of overcrowding by solving the question of the housing of the working classes.

3. *Oil Fuel.* *By* A. M. BELL.

The increasing interest and steady progress in the employment of oil as fuel for various purposes suggests the compilation of the paper submitted.

Oil fuel has been a favourite field for the ingenuity of inventors for many years. The first applications appear to have been made in France, but numerous

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experimental installations have followed, and in Russia its general employment may be said to have commenced about 1870, when the development of the enormous oil supplies of the Apcheron Peninsula became an accomplished fact, and the first oil-fuel steamer appeared on the Caspian Sea.

In the United States, where the crude oil of the Pennsylvanian field contains a larger percentage of light oil, the use of liquid fuel until recently has been on a less extended scale; now, however, the discoveries in California and Texas have provided enormous supplies of crude oil, practically only suitable for this service and great advances have consequently been made in its use.

In this country many attempts have been made, but owing to the absence of regular supplies progress has not been so rapid as in the cases mentioned above. The manufacture of oil gas and carburetted water gas has, however, thrown on the market products of a character only suitable for fuel, and rendered its adoption possible on a limited scale.

The different methods of burning oil fuel may be summarised as follows: (1) those wherein it is burned in bulk form; (2) in a sprayed or atomised condition; and (3) consumed as vapour or gas. The first mentioned procedure has received most application in Russia, whereas the last has enlisted most attention in the United States owing to the lighter character of the oils available. Generally, however, the second or spraying system may be looked upon as the favourite, most generally adopted, and probably the most successful; hence the chief attempts at improvement appear to have been devoted to it. The most effective device is doubtless that requiring the least quantity of the atomising agent (steam or compressed air) for operation, and until recently the attention of workers in this direction has been centred on the burner employed, the construction of the furnace, which is of as much importance for a good result, being somewhat neglected. Further, a due consideration of the admittance, distribution, and temperature of the air for combustion is absolutely essential to success.

The latest developments of spraying apparatus point to the employment of oil fuel under pressure, heated to a high temperature, sprayed with dry steam, and the fire fed with heated air for combustion.

For steamers the use of oil fuel possesses advantages over coal in excess of those which can be urged in its favour when employed on land: reduced storage space, less number of men required, an increased steaming capacity from a given supply of fuel, are points of the greatest value from the marine aspect of the question.

For locomotives the assistance of oil fuel is valuable on the long runs without stopping, now becoming common, the difficulties of firing and the trouble from dirty fires being no longer present. The application in this direction has been much improved and simplified during the past few years with a view of securing the reliability of the apparatus under all conditions of service, and the method devised by Mr. Holden, of the Great Eastern Railway, of arranging the apparatus has been extensively adopted owing to the opportunities it affords for the use of solid or liquid fuel, or both, at will or as circumstances may make most desirable.

In Russia and the United States some hundreds of locomotives are regularly running, using oil as fuel; and numerous examples are to be found in this and other countries where coal has become an expensive commodity.

For furnace work oil fuel offers unique advantages, and many interesting applications have been made to meet the special requirements of annealing, tempering, metal melting, brazing, &c. In glass making and enamelling oil fuel has met with considerable adoption, and portable furnaces of all kinds are successfully operated with it; in bridge-work, shipbuilding, &c., oil-fired rivet furnaces are to be preferred to any form of solid fuel-heating device.

In storage oil fuel has many favourable features. It occupies a minimum of space, does not deteriorate by exposure, and is easier of transportation and distribution.

In the Far East and many Oriental countries the importation of oil fuel has now become a regular undertaking, and supplies are guaranteed in many cases where wood has become scarce and imported coal an almost prohibitive article.

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4. *Further Experiences with the Infantry Range-finder.* By Professor George Forbes, *F.R.S.*

This paper deals with the facility of learning to use the range-finder, its employment with artillery, and its accuracy in the hands of men selected with good eyesight.

In 1901 the author exhibited to the British Association his portable stereoscopic infantry range-finder, and gave the results of trials to test its accuracy.

To test its durability in the field, the author used it in the South African war, with Colonel Crabbe's column, under General Sir John French, and the reports upon its accuracy and durability in the field were certainly satisfactory. The results obtained in actual war and under fire were given to the Association at the last meeting.

The only point remaining to be established, in order to prove its entire suitability for infantry, is the facility of learning its use, some people having a suspicion that the stereoscopic effect would not be obtained by a large proportion of ordinary men. The following results show that out of over fifty men who gave the range-finder a trial of five minutes, not one failed to take ranges with considerable accuracy, and only one was not sufficiently interested to give the five minutes' necessary attention to it.

These trials took place at Aldershot under a War Office Committee, and at Bisley under the auspices of the National Rifle Association. In the former case three sergeants and five privates were chosen haphazard for instruction; and, although the weather was most unsuitable, not one of them failed, and the progress made by all of them was most satisfactory. At the Bisley trials forty-one men took instruction, and all—with the single exception already mentioned—were able within half an hour to take easy ranges with accuracy; while fifteen of them presented themselves for a prize competition in its use. The results obtained by the winners of the first two prizes at five distances chosen, up to 1,670 yards, were: Sergeant F. E. Pollard had an average error of 10·8 yards, or 1·1 per cent. of the average distance; and his average time for an observation was 12 seconds. Colonel Milner's average error was 11·4 yards, or 1·2 per cent. of the average distance; and his average time for an observation was 14·5 seconds. It is worthy of note that not one of the competitors had previously received more than one hour's instruction or practice, while Sergeant Pollard, the winner of the first prize, had never seen the instrument until about half an hour before he actually competed.

Experiments were made with the infantry range-finder in July 1903 on Salisbury Plain with artillery. The object sought was to correct for the error of the day, including variations in ammunition and weather, more quickly than is possible by the existing system of bracketing by firing the first shot with shrapnel which bursts in the air, taking the range of this burst—which is seen as a white cloud—and making the necessary correction for the second shot, which would then be on the target. The results obtained at two ranges are as follows, the distance short or over, as found by the range-finder, being first given, and then the same distance as estimated by the range-party near the target, for each shot:

I. Range, 2,840 yards—(1) 200 short, 150 short; (2) 100 short, 200 short; (3) 120 short, 170 short; (4) 200 short, 210 short; (5) 150 short, 160 short; (6) 100 short, 110 short; (7) 60 short, 50 short.

II. Range, 3,535 yards—(1) 250 short, 150 short; (2) 350 short, 280 short; (3) 100 over, 40 over; (4) 120 short, 130 short; (5) 200 short, 60 short; (6) 220 short, 140 short; (7) 80 over, 30 over.

The above records include every shot observed both by the range-finder and the range-party during the period referred to, and prove the importance of making further use of this method.

The great accuracy of this range-finder in the hands of men with ordinary eyesight made it desirable to find out what could be done by selected men with

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good eyesight—those, for example, who had established a reputation for good rifle-shooting. The following are a few examples of Mr. F. E. Pollard's work with different specimens of range-finder at long distances:

I. Ben Vrackie at Pitlochry, range-finder No. 11: the consecutive readings were 5,000, 5,200, 5,100, 5,200, 5,200; mean, 5,140. Distance, from Ordnance Survey, 5,210 yards.

II. The same object and distance, range-finder No. 10: 5,150, 5,100, 5,000, 5,000, 5,200; mean, 5,090.

III. Same object and distance, Base No. 2, Binocular No. 10: 5,200, 4,950, 5,150, 5,200; mean of four observations, 5,125.

IV. Same object from a different point, range-finder No. 12: 6,050, 6,100, 6,200, 6,200, 6,150; mean, 6,140; distance, from Ordnance Survey, 6,200 yards.

V. An example of a test of No. 10 range-finder made by Mr. Pollard when ignorant of the true distance, the range-finder having been adjusted two months previously, and having travelled hundreds of miles and been used frequently in the interval. Observing station: Pouton, Sunbury, Middlesex. Object observed: Tower of Holloway College; indistinctly visible. Successive readings: 10,750, 10,000, 10,550, 10,000, 9,800, 9,800, 9,850; mean, 10,236; distance on Ordnance Survey, 10,200 yards. It will be obvious that even with the maximum error of all these readings at a distance of almost six miles, this instrument, designed only for use with infantry up to 3,000 yards, is capable, in the hands of a skilled observer, of giving results of the utmost value not only to artillerists but also to surveyors and travellers.

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5. *Water-supply in South-west Lancashire.* *By* Joseph Parry, *M.Inst.C.E.*

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6. *Rainfall on the River Bann, County Down, Ireland, at Banbridge, and at Lough Island Reavy Reservoir.* *By* John Smyth, *M.A.*, *M.Inst.C.E.I.*

The author read a paper at the Belfast meeting in 1876 on the rainfall of Banbridge for ten years 1864–1873; also on the rainfall of Ulster. He now gives a summary of the rainfall at Banbridge for forty years, 1862–1901. The average for the whole period was 31·1; the wettest year, 1872, with 46·6 inch fall; the driest, 1887, with 23·1 inches fall. The greatest fall in twenty-four hours, 2·3 inches, on October 12, 1865. On July 4, 1883, at 7.30 P.M., 1·6 inch fell in one hour. The greatest ten years' average was 33·3 from 1872–1881; the least, 29·1, from 1862–1871. The average rainfall at the reservoir, twenty miles farther up the stream than Banbridge, for the same forty years, was 44 inches.

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7. *On the Rate of Fall of Rain at Seathwaite.* *By* Hugh Robert Mill, *D.Sc.*, *LL.D.*

A recording rain-gauge on Negretti and Zambra's pattern was established at Seathwaite, in Cumberland, in the wettest part of the Lake District, in July 1899, by the late Mr. Symons, and records were obtained up to the end of December 1900. Ordinary observations of rainfall are available for many years at the same place, and as the average of thirty-eight years (1865–1902) the rate of fall is ·614 inch per rainy day, a rainy day being one on which more than ·005 inch falls; and on the average there are 216 such days in the year, the total mean annual rainfall being 132·53 inches. The total number of rainfall days for the eighteen months (July 1899–December 1900) was 350, the total rainfall by the recording-gauge 182·91 inches, or at the rate of ·523 inch per rainy day. The average duration of rainfall was four and three-quarter hours per rainy day, or nearly double the duration in London. During the period in question rain fell during 1,695 hours, or at an average rate, when raining, of ·108 inch per hour.

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Taking account of continuous falls of six hours' duration or longer, there were ninety-one occasions with a total duration of 822 hours, a total fall of 99·99 inches and an average rate of ·122 inch per hour.

Taking account of falls exceeding ·50 inch in amount, there were eighty-six occasions with a total duration of 703½ hours, a total fall of 109·47 inches, and an average rate of ·156 inch per hour.

The maximum rate at which ½ inch or more of rain fell during the eighteen months in question was ·560 inch per hour, a total of 1·40 inch falling in two and a half hours from 8 to 10.30 P.M. on September 21, 1899. This is a trifling rate compared with the fall of from 2 to 3 inches in an hour, which may occur in a thunderstorm in any of the drier parts of the country; and even if attention is confined to falls of one hour only, no instance occurred of a rate equal to ·75 inch per hour. The peculiarity of the Seathwaite rainfall seems to be its low duration and comparatively small rate of fall. The longest and heaviest shower in the period considered was nineteen and a quarter hours, during which 3·59 inches of rain fell, at an average rate of ·186 inch per hour.

The duration of rainfall during daylight (sunrise to sunset) and during darkness (sunset to sunrise) was calculated for the year 1900, with the result:—

	Number of Hours' Rain	Amount of Rain. Inches	Rate. Inches per Hour	Number of Days
Daylight . .	595	61·28	·103	197
Darkness . .	596½	64·66	·108	172

This shows that the duration of rainfall in daylight and darkness was practically identical, but that there was a very slightly greater intensity in the night than during the day.

It is very desirable to extend the use of recording rain-gauges, and to be of much value the scale should be open enough to give exact readings, preferably giving a separate record strip for each day.

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8. *On the Tidal Régime of the River Mersey.* *By* James N. Shoolbred, *B.A.*, *M.Inst.C.E.*

Since the last meeting of the British Association at Southport in 1883, twenty years ago, many circumstances have occurred to change the tidal régime of the River Mersey. Of these the principal are:—(1) the removal by dredging of the ridge of the bar (to a depth of seventeen feet) which closes the seaward extremities of the river in the estuary; (2) the rectification of the sides of the channel within the river, due to the construction of the dock and other walls, on both sides of the river, but principally on the Bootle shore of the Lancashire side.

In the upper portion of the tidal river the Manchester Ship Canal has also, probably, contributed somewhat to changes in the tidal régime; though to what extent is a matter of dispute.

The two first-named causes have undoubtedly produced very considerable effects by the freer passage for the ingress and the outlet of the tidal water, due to the partial removal of the impeding wall formed by the bar, and by the readier flow and ebb of the tidal stream, afforded by the smooth faces of the walls at the more recently constructed Northern Docks and elsewhere.

The result of the dredging operations, alone, has been to provide throughout the entire distance, from the bar throughout the Queen's Channel, and right up to the landing stage, a central waterway having a depth of twenty-seven feet at low water of the lowest spring tides; while at high water of the same tides there is a depth of fifty-eight feet. This has entailed, during the period 1890-1902, the dredging of 29 million tons of sand at the bar, of 46 millions in the estuary channels, and of 10 millions in the river itself, making a total of 85 million tons.

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Further details of the improved condition, for the purposes of navigation, are also added in the paper.

But another object of the paper is to endeavour to provide data for the recalculation of the data of the tidal régime, as amended by the above results, by what is known as the method of 'harmonic analysis.'

This method of 'harmonic analysis' of the tides was first brought before the British Association in 1872 in a long report by Sir William Thomson (now Lord Kelvin), Professor J. C. Adams, Professor Rankine, and others. A further report, however, on the subject, and illustrative of the method, as used in the reduction of the Indian tidal observations, was presented at the 1883 meeting in Southport by Professor G. H. Darwin and Professor J. C. Adams.

Since then, in 1885, Professor G. H. Darwin has communicated to the Royal Society the data, resulting from the harmonic analysis of the tides at Liverpool.

It is urged, however—and apparently on good authority—that the actual data now afforded by the tidal régime of the Mersey, resulting from the changes referred to at the commencement of the paper, are such as to render it advisable to again submit the Mersey tides to a further examination by 'harmonic analysis.'

The writer would suggest that a Committee might be formed, with the object of obtaining the necessary Tidal data, and in a form suitable for Harmonic Analysis thereof.

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9. *History of the Discovery of Natural Gas in Sussex, Heathfield District.* *By* RICHARD PEARSON.

The first find of gas which has come to my knowledge was made in 1836 at Hawkhurst in West Sussex.

Natural gas next appeared during the famous sub-Wealden boring of 1873–75, at a place called Netherfield. The sub-Wealden was started to commemorate the visit of the British Association to Brighton, 1872. Mr. Topley records at 602 feet a bed 1 foot thick, very rich in petroleum. This was in the Kimmeridge clay, 290 feet from the surface.

Willet records on this bore: 'Indications of petroleum became more distinct at about 160 feet from top of the Kimmeridge clay; all below that depth is more or less impregnated with petroleum.'

Natural gas was not used to any great extent in America before 1885. It was about that date that Mr. Andrew Carnegie used natural gas in his steelworks.

At Heathfield, some time ago, a firm of well-drillers were boring a well for water on the site of what is now the Heathfield Hotel. At 300 feet the borers met an inflammable gas; but as they were seeking for water, and none was reached, the borehole was cemented up and left.

In August 1896 men employed by the same firm were at work boring a well for the L. B. & S. C. Railway Company for water; at a depth of 300 feet they also found an inflammable gas. But no water was reached even when another 100 feet had been sunk.

Three years afterwards the railway company decided to put the gas to some useful purpose, and ever since the railway station has been lit with natural gas. The consumption is about 1,000 cubic feet per day.

Hearing of this very practical outcome of the second discovery, I expected to hear also that explorations would be made to discover the extent of the gas-bearing area. But finding that no further steps were taken, I communicated with some American friends, who asked me to take steps.

I located positions for six exploratory boreholes to be made; we commenced boring, and in all of the boreholes we have struck gas, at levels varying from 300 to 400 feet from the surface, the farthest borehole of the six being distant some 1,200 yards from the railway station.

These six boreholes are started in the geological formation known as the Hastings bed, which—in the Heathfield district—lies some 400 feet geologically

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above the sub-Wealden boring at Netherfield, which was started in the Purbeck bed. This Hastings bed is composed principally of sandstones and iron bands which make it a 'cap' admirably adapted for acting as a natural holder for gaseous volumes.

Heathfield is built on the well-known Mid-Sussex anti-clinal. The sub-Wealden boring, started in the Purbeck bed, situated some nine miles east, is on the same anti-clinal. This fact conclusively proves the relative identity of the two discoveries.

The Purbeck is well known to be bituminous throughout. The Kimmeridge clay, which lies some 200 feet below the Purbeck, has been proved to be the thickest bed of Kimmeridge in England, and 250 feet of this bed is known to be of a very bituminous nature. Again, the Oxford, lying below the Kimmeridge, is known to be also bituminous.

In searching for natural gas in the United States, three things are kept in view:—

Firstly. Have the rocks been disturbed? (If so, no further time need be wasted looking for gas.)

Secondly. Is it an anti-clinal formation?

Thirdly. Are there any known bituminous beds below?

Holding these points in view, I may say that:—

1. In this part of Sussex we have the iron formation of the Hastings sands practically undisturbed.

2. It is well known to geologists that the North and South Downs are simply the outliers of an enormous anti-clinal.

3. There are three successive bituminous beds proved to lie immediately under the sandstones.

At Mayfield, about five miles from Heathfield, we have commenced boring in two positions on the Tunbridge Wells sands.

We are now boring over some 200 square miles in the county of Sussex. At Heathfield we are already supplying between seventy and eighty houses with natural gas. We have obtained facilities from the L. B. & S. C. Railway Company to lay our conduit pipes along their lines.

The Composition of Heathfield Natural Gas.—The Sussex gas in its natural state gives, in an ordinary 'Argand' burner, a light of about 12-candle power.

Professor Dixon, who I believe analysed Heathfield gas for the Royal Coal Commission, has put on record figures which account for the high illuminating value it has been proved to possess.

He gives as its constituents:—

Methane	93·4 per cent.
Ethane	3·0 „
Nitrogen	2·7 „
Carbonic oxide	0·9 „

The great point in the future of Heathfield gas will be its value as used to provide machine power.

The engines in use at Heathfield consume about 13 cubic feet to 15 per horse power.

The heating power that is to be obtained from a gas containing 93 per cent. of methane is obvious.

In an estimate made last year, it transpired that in America one million households and four million people were furnished with this ideal fuel and light.

The ironworks of the Wealden area employed some fifty thousand men in 1750, when the coal in the North took the iron-working away from the South. To-day not an ounce of iron is smelted.

The fuel is the cheapest in the world, the cost of carriage will be obviated,

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and in addition to seeing the old industries revived, we shall have opened up an enormous tract of country for new industries which at present is devoted solely to agriculture.

The pressure general at Heathfield varies from 134 lb. to 200 lb. per square inch. As to the permanency of the gas, I may state that in China natural gas—from identically similar geological formations—has been used for evaporating salt for over one thousand years.

The United States have some eleven thousand wells bored; we have at present nine, and are in course of sinking ten others.

The comparison of gaseous fuels is approximately as follows:—

Per 1,000 *cubic feet at* 40° *F., and at Atmospheric Pressure.*

Natural gas	1,100,000 units of heat
Coal gas	735,000 „
Water gas	322,000 „
Producer gas (heated)	156,000 „

WEDNESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *The Effect of Traffic and Weather on Macadamised Roads, and the Prevention of Dust. By* T. AITKEN, *Assoc.M.Inst.C.E.*

This paper deals with the problem of improving the structural condition of macadamised roads to withstand the effect of weather and the ever-increasing fast vehicular traffic, especially that of motor cars.

After describing the methods followed in connection with the making and repairing of macadamised roads, the author deals in brief with the principal points to be observed when first-class work is required. The quality of the metalling (embracing the trap rocks generally, but more particularly basalt, andesite, felsite, diabase, and some dolerites, being very much superior and less greasy in wet weather than limestone and most granites). The binding material is specially noticed, and also the effect of weather and traffic is described.

The smoothness of macadamised roads when properly made compares favourably with street pavements as tested by the viagraph. It is also pointed out that macadamised roads begin to wear at a comparatively early period after being repaired. The causes of this are stated and the probable remedy, so as to ensure greater cementitious power between the component parts of macadamised roads. It is specially pointed out that the binding and not the metalling should be treated, and preferably after the road has been repaired, when contour and surface are at their best. Different methods, recently carried out, of treating macadamised roads with petroleum or tar are mentioned, and the author describes a method by which tar in its natural state can be applied to a road surface in the form of a fine spray, under pressure, the penetration into the binding being from 2 to 4 inches. The experiments carried out show a decidedly improved surface, but adverse climatic conditions, extending for a considerable time past, have precluded information of a reliable nature being recorded. It is pointed out that the time has fully arrived for further improving the structural condition of macadamised roads, and it is to be hoped that the methods adopted and described in this paper will tend in that direction and prove successful.

2. *Pendulum Apparatus for Testing Steel as regards Brittleness. By* E. G. IZOD.

The ability of materials in general and steel in particular to withstand shock is a subject of great importance to all engineers, and this paper gives an outline of the systems generally in use for carrying out brittleness tests, with remarks on

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each; and *further* explains the use of the pendulum apparatus, as used by Messrs. Willans and Robinson, with the reasons that led to its adoption.

Tests by shock or tests for brittleness have from the earliest times been used by engineers, especially on the Continent; and Swedenborg, in 1734, gives some interesting particulars of the rule-of-thumb tests carried out by purchasers of iron in those days; and in nearly every case an impact or brittleness test was used, which though only empirical was no doubt all that was required, and gave a deal of useful information.

At the present time, probably owing to the state of perfection to which the testing machine has been brought, there is too much inclination to neglect other properties of material which the usual tests do not detect, but which are quite as important as the usual standard physical tests; and that this is so is shown by M. Fremont's paper, published by the Société d'Encouragement pour l'Industrie Nationale, September 1901, in which he throws an extraordinary light on the brittleness question, and gives several instances where serious fractures in structural and other steel were not accounted for by any of the ordinary testing methods, but were readily explained when tested for brittleness by an impact machine.

At Messrs. Willans & Robinson's, Rugby, it has long been felt that a method of testing such as used by M. Fremont and others was wanted to detect the reason for certain fractures which were inexplicable by the ordinary methods used; and an experimental pendulum impact machine was made, and the tests carried out with it gave promise of such good results that a standard machine was made and is in use at the present time, giving results which gain in importance with every series of experiments carried out on it.

Many types of impact machines are used, but the pendulum form of apparatus seems to give most satisfactory results: it can be calibrated to give direct readings for energy absorbed, and lends itself to very quick working even by an inexperienced operator.

The idea of the arrangement is as follows:—A weight is suspended pendulum-wise on a stiff rod, which swings from a centre designed to be as frictionless as possible. This weight or tup is then moved out of the vertical and allowed to fall on to the free end of a test-piece gripped by the other end in a vice, the specimen being *notched* to locate the break, the height of fall being always made sufficient to cause fracture with *one blow*. A suitable measuring arrangement is used to record the energy remaining in the weight after fracture of test-piece has occurred; and this subtracted from the calculated energy in the tup before fracture gives the energy required to break the specimen.

Measurements are taken of the test-piece, and results are transferred to equivalent energy absorbed on specimen one inch square.

The paper is accompanied by drawings of the apparatus and tables of results obtained.

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3. *Permanent Set in Cast Iron due to Small Stresses, and its Bearing on the Design of Piston Rings and Springs.* *By* C. H. Wingfield.

Some of Messrs. Willans & Robinson's steam packing rings, each consisting of an outer cast-iron 'ring' of uniform section, and of the same diameter as the bored cylinder in which it worked, and an inner cast-iron 'spring' ring of section varying as described in vol. II. of Unwin's 'Machine Design,' under the heading 'Theory of a Cast-iron Spring Ring,' were tested as to equality of their outward pressures per inch of circumference. Whereas by published formulæ they should have agreed in this respect, it was found that they actually differed considerably. Some springs made specially for the purpose, and having different amounts of 'follow,'[1] but alike in other respects, were then experimented with by being forced into circular ring-gauges, and being removed and measured after periods

[1] By 'follow' is meant the difference of diameters of the spring when free and when forced into its working position. This difference enabled the combined ring and spring to follow up and compensate for wear.

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varying from one minute to forty-eight hours. It was found that their diameters were reduced by this treatment, the greater part of the permanent set having taken place during the first fifteen minutes, and that its amount increased with the 'follow' originally given to the springs. It was also found that a measurable amount of set was producible by merely squeezing the rings between the hands.

After the rings had been compressed to a definite size for two days or more they acted as reliable springs so long as the initial amount of compression was not exceeded.

Some slight inaccuracies in published formulæ applicable to rings formed of materials such as steel, not liable to permanent set from such light loads as piston rings are subject to, were briefly alluded to and a correct formula given; but it was pointed out that that usually published was simpler and sufficiently accurate in use, though not applicable to cast iron. Some elaborate formulæ had been published by E. V. Clark on the 'Theory of Cast-iron Beams,'[1] and could perhaps be modified to suit the special case under consideration; but they were not convenient, and the proportions found by direct experiment appeared preferable; moreover the amount of set, and consequently the actual (as compared with the initial) follow, could only be found by trial.

The amount of 'spring' in a cast-iron ring with loads not exceeding that which had produced permanent set was much greater than appeared to be generally realised. A spring ring about 5½ inches diameter, 0·25 inch thick radially and with its ends about 1⅛ inch apart (after deducting the permanent set), could be bent until they met, and when released they sprang back again to 1⅛ inch apart.

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4. *A further Note on Gas-engine Explosions.* *By* H. E. WIMPERIS.

In the autumn of 1901 the Institution of Mechanical Engineers published the Second Report of the Gas-engine Research Committee drawn up by Professor F. W. Burstall, and in this manner there was presented to the scientific and engineering world a very large mass of experimental results containing most valuable information regarding the internal economy of gas engines. Professor Burstall comes to several conclusions, prominent among which is his contention that the results of his experiments cannot be reconciled without the use of a variable specific heat.

The writer has already published in the engineering press an account of certain consequences which follow from this hypothesis, but before the matter could be considered upon a satisfactory basis it was necessary that the classical experiments of Mr. D. Clerk and Mr. Grover should be brought into line. In a paper contributed to the British Association last year, the writer analysed Mr D. Clerk's results and showed that they were in complete harmony with the variable specific heat hypothesis. In the present paper the writer deals with the experiments of Mr. Grover, and shows not only that there is no inconsistency between this hypothesis and Mr. Grover's results, but that by its adoption the explanation of certain difficulties in these results is the more easily given.

Thus in the present paper and in the one submitted last year the writer claims to have achieved the object with which he set out—namely to ascertain whether there was anything in past records of experimental work with gas engines which would prove to be incompatible with the adoption of a variable specific heat in all future gas-engine calculations. The conclusion is that there is nothing in the classical investigations of Mr. D. Clerk or Mr. Grover which should afford any ground for hesitation in the matter.

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5. *Preliminary Experiments on Air Friction.* *By* WM. ODELL, *A.R.C.Sc.*

These experiments were begun with the object of finding a convenient method of determining the power wasted by the windage of flywheels and dynamo armatures. The experiments described at length were made with paper discs, which were mounted on the shaft of an electric motor.

[1] *Minutes of Proceedings Institution of Civil Engineers*, vol. cxlix. p. 313.

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The excitation was kept constant, so that the torque was proportional to the current. Thus the extra current required to maintain a given speed after the disc had been fixed to the shaft gave the torque absorbed by the disc.

There was found to be an angular speed for each disc above which the torque was accurately proportional to about the 2·5th power of the speed. This critical speed appeared to vary inversely as the square of the diameter. Below it the law followed was of a lower degree; but owing to the multiplication of errors of measurement no definite conclusion as to its exact nature was arrived at.

As the three discs originally tried gave uncertain results as to the effects of size, a much larger one, nearly 4 feet in diameter, was also tried; and as a result of all the experiments it was concluded that the torque varies as about the 5·5th power of the diameter.

To give an idea of the amount of power thus absorbed, it may be stated that a disc of 47 inches required $\frac{1}{10}$ H.P. to keep up a constant speed of 500 revolutions per minute, and that if the above law holds a 9-foot disc would absorb 10 H.P. at the same speed.

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6. *On Monophase Induction Repulsion Motors.*

By William Cramp, *A.M.I.E.E.*

The repulsion motor has in the single-phase system the functions of the direct series motor in the direct current system of electrical distribution, possessing the advantage of a large starting torque. In construction the repulsion resembles the direct current motor, with the field laminated; the armature-brushes are short-circuited, and the field only is connected to the supply-mains, which constitutes a great advantage over the alternate-current series motor. Two classes of repulsion motors are examined: (1) those with definite poles, and (2) those without definite poles; and each, again, may have either (*a*) open-circuited or (*b*) closed-circuited rotors. Theoretically the repulsion motor is always a special case of the alternate-current transformer. The action is shown by a model which takes into separate account the phase in time, and the position in space of the current or of the field produced thereby. Class 1 have usually smaller starting torque, a lower maximum speed, and a more sparkless commutation than Class 2. The locus of the extremity of the primary current vector plotted for current and power-factor is approximately a narrow semi-ellipse; the higher the ratio pole-arc : pole-pitch, the more nearly does the curve approach a semicircle, provided that the brushes be moved as the load alters.

Open-circuit motors have their current formula and calculations complicated by the presence of an exponential term, which also renders commutation more difficult and tends to reduce the torque of the motor and to shift the rotor current in phase a little.

The author has tried practically three different motors, each of which was repeatedly varied in its details; he finds that in every case by suitable subdivision of the armature-coils the motor may be rendered sparkless. The starting torque may be made very large indeed, one rotor starting under full load, with at most only one-and-a-half times full-load current.

Other practical points are: (1) the advantage of working with high air-gap density; (2) the need for extreme rigidity of the bearings to avoid contact between rotor and stator; (3) the capability of the machine to run well above synchronism.

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7. *On the Ventilation of Tube Railways.*

By J. W. Thomas, *F.I.C., F.C.S.*

The physical conditions essential to good ventilation in tube railways are chiefly dealt with in the paper, and it is calculated that the forces brought into play by the moving trains and the natural heat of the tubes will be ample if properly directed. In tube railways, if B is the centre of three stations, the down train moving from A to B will draw air from the A station into the tube and expel it

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in the B station, and the up train moving from C to B will draw air from the C station into the tube and expel it in the B station. Three stations are thus directly involved, and a triple-station arrangement will best fulfil the physical conditions.

Owing to the elasticity of air the outlets for expelling the vitiated atmosphere must not be situated far from the points of greatest compression, and should begin in the centre of each station underground and end in the open air above the station at the surface.

For the same reason the intakes for fresh air should be close to the points where the sudden expansion of the air begins. These points are at the ends of the tubes which the moving trains *enter*.

Doors can be fixed at the ends of the two tubes which the trains *enter* in each station, and closed behind the last trains at night, so that the fresh air brought into the end of the tube immediately beyond the doors will drive out the foul air into the next station by natural ventilating pressure.

Conclusion.—The providing of fresh air inlets inside the ends of the tubes which the trains enter, with an outlet shaft in the centre of each station, will enable the moving trains to draw in and expel enough air to keep the atmosphere in good condition, even in hot summer weather. In addition to this, however, there are two auxiliary aids to ventilation which enable the station masters to make *certain* that the state of the atmosphere in the tubes is satisfactory.

1. Having inlets and outlets as above, the timing of the departure of the up and down trains as they move towards the *same* station will enable enormous volumes of air to be driven to the surface, and a corresponding volume will be drawn in.

2. By closing the doors after some of the trains as they leave the stations fresh air must be drawn into the tubes.

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8. *Experiments in Gas Explosion.*

By L. BAIRSTOW *and* A. D. ALEXANDER.

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9. *A new Form of Mirror Extensometer.* *By* JOHN MORROW, *M.Sc.*

Mirror extensometers have not been much used in this country. They are not self-contained, and to obtain the mean extension of a specimen two sets of readings are necessary. There may be errors due to slight alterations in the positions of the specimen, the telescope, or the scale. In the instrument described an attempt has been made to avoid these defects and to obtain the mean extension by a single observation.

Its special feature is the use of two mirrors placed side by side, one of which is attached rigidly to the instrument and the other arranged to tilt about a horizontal line when the specimen extends. The tilting mirror is carried on a piece of hardened steel of diamond-shaped section. One edge of this base is pressed against a piece attached to the upper pair of set-screws, and the opposite edge similarly against a piece from the lower screws. The four set-screws serve to attach the instrument to the specimen, and are situated at opposite ends of two parallel diameters of the test-piece. Any change in the mean vertical distance between them is thus a measure of the alteration in length of the centre-line of the specimen, and is accompanied by a slight tilting of the mirror. A telescope is so placed that the two images of a scale are seen close together, and to measure extensions a convenient mark on the fixed image is taken as an index, and the reading coinciding with it on the other image is noted each time the load is altered. The instrument has proved very satisfactory with a magnification of 1600, when the extensions can be measured to the nearest $\frac{1}{40000}$ of an inch.

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SECTION H.—ANTHROPOLOGY.

PRESIDENT OF THE SECTION—Professor JOHNSON SYMINGTON, M.D., F.R.S., F.R.S.E.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

IT is now nearly twenty years since Anthropology attained to the dignity of being awarded a special and independent Section in this Association, and I believe it is generally admitted that during this period the valuable nature of many of the contributions, the vigour of the discussions, and the large attendance of members have amply justified the establishment and continued existence of this Section.

While the multifarious and diverse nature of the subjects which are grouped under the term Anthropology gives a variety and a breadth to our proceedings which are very refreshing in this age of minute specialism, I feel that it adds very considerably to the difficulty of selecting a subject for a Presidential Address which will prove of general interest.

A survey of the recent advances in our knowledge of the many important questions which come within the scope of this Section would cover too wide a field for the time at my disposal, while a critical examination of the various problems that still await solution might expose me to the temptation of pronouncing opinions on subjects regarding which I could not speak with any real knowledge or experience. To avoid such risks I have decided to limit my remarks to a subject which comes within the range of my own special studies, and to invite your attention to a consideration of some problems arising from the variations in the development of the skull and the brain.

Since the institution of this Section the development, growth, and racial peculiarities of both skull and brain, and the relation of these two organs to each other, have attracted an ever-increasing amount of attention. The introduction of new and improved methods for the study of the structure of the brain and the activity of an able band of experimentalists have revolutionised our knowledge of the anatomy and physiology of the higher nerve centres.

The value of the results thus obtained is greatly enhanced by the consciousness that they bear the promise of still greater advances in the near future. If the results obtained by the craniologist have been less marked, this arises mainly from the nature of the subject, and is certainly not due to any lack of energy on their part. Our craniological collections are continually increasing, and the various prehistoric skull-caps from the Neanderthal to the Trinil still form the basis of interesting and valuable memoirs.

While the additions to our general knowledge of cerebral anatomy and physiology have been so striking, those aspects of these subjects which are of special anthropological interest have made comparatively slight progress, and cannot compare in extent and importance with the advantages based upon a study of fossil and recent crania. These facts admit of a ready explanation. Brains of anthropo-

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logical interest are usually difficult to procure and to keep, and require the use of special and complicated methods for their satisfactory examination, while skulls of the leading races of mankind are readily collected, preserved, and studied. Hence it follows that the crania in our anthropological collections are as numerous, well preserved, and varied as the brains are few in number and defective, both in their state of preservation and representative character. It may reasonably be anticipated that improved methods of preservation and the growing recognition on the part of anthropologists, museum curators, and collectors of the importance of a study of the brain itself will to some extent at least remedy these defects; but so far as prehistoric man is concerned, we can never hope to have any direct evidence of the condition of his higher nerve centres, and must depend for an estimate of his cerebral development upon those more or less perfect skulls which fortunately have resisted for so many ages the corroding hand of time.

I presume we will all admit that the main value of a good collection of human skulls depends upon the light which they can be made to throw upon the relative development of the brains of different races. Such collections possess few, if any, brains taken from these or corresponding skulls, and we are thus dependent upon the study of the skulls alone for an estimate of brain development.

Vigorous attacks have not unfrequently been made upon the craniometric systems at present in general use, and the elaborate tables, compiled with so much trouble, giving the circumference, diameters, and corresponding indices of various parts of the skull, are held to afford but little information as to the real nature of skull variations, however useful they may be for purposes of classification. While by no means prepared to express entire agreement with these critics, I must admit that craniologists as a whole have concentrated their attention mainly on the external contour of the skull, and have paid comparatively little attention to the form of the cranial cavity. The outer surface of the cranium presents features which are due to other factors than brain development, and an examination of the cranial cavity not only gives us important information as to brain form, but by affording a comparison between the external and internal surfaces of the cranial wall it gives a valuable clue to the real significance of the external configuration. Beyond determining its capacity we can do but little towards an exact investigation of the cranial cavity without making a section of the skull. Forty years ago Professor Huxley, in his work 'On the Evidence of Man's Place in Nature,' showed the importance of a comparison of the basal with the vaulted portion of the skull, and maintained that until it should become 'an opprobrium to an ethnological collection to possess a single skull which is not bisected longitudinally' there would be 'no safe basis for that ethnological craniology which aspires to give the anatomical characters of the crania of the different races of mankind.' Professor Cleland and Sir William Turner have also insisted upon this method of examination, and only two years ago Professor D. J. Cunningham, in his Presidential Address to this Section, quoted, with approval, the forcible language of Huxley. The curators of craniological collections appear, however, to possess an invincible objection to any such treatment of the specimens under their care. Even in the Hunterian Museum in London, where Huxley himself worked at this subject, among several thousands of skulls, scarcely any have been bisected longitudinally, or had the cranial cavity exposed by a section in any other direction. The method advocated so strongly by Huxley is not only essential to a thorough study of the relations of basi-cranial axis to the vault of the cranium and to the facial portion of the skull, but also permits of casts being taken of the cranial cavity; a procedure which, I would venture to suggest, has been too much neglected by craniologists.

Every student of anatomy is familiar with the finger-like depressions on the inner surface of the cranial wall, which are described as the impress of the cerebral convolutions; but their exact distribution and the degree to which they are developed according to age, sex, race, &c. still remain to be definitely determined. Indeed, there appears to be a considerable difference of opinion as to the degree of approximation of the outer surface of the brain to the inner surface of the cranial wall. Thus the brain is frequently described as lying upon a water-bed, or as swimming in the cerebro-spinal fluid, while Hyrtle speaks of this fluid as a

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'ligamentum suspensorium' for the brain. Such descriptions are misleading when applied to the relation of the cerebral convolutions to the skull. There are, it is true, certain parts of the brain which are surrounded and separated from the skull by a considerable amount of fluid. These, however, are mainly the lower portions, such as the medulla oblongata and pons Varolii, which may be regarded as prolongations of the spinal cord into the cranial cavity. As they contain the centres controlling the action of the circulatory and respiratory organs, they are the most vital parts of the central nervous system, and hence need special protection. They are not, however, concerned with the regulation of complicated voluntary movements, the reception and storage of sensory impressions from lower centres, and the activity of the various mental processes. These functions we must associate with the higher parts of the brain, and especially with the convolutions of the cerebral hemispheres.

If a cast be taken of the cranial cavity and compared with the brain which had previously been carefully hardened *in situ* before removal, it will be found that the cast not only corresponds in its general form to that of the brain, but shows a considerable number of the cerebral fissures and convolutions. This moulding of the inner surface of the skull to the adjacent portions of the cerebral hemispheres is usually much more marked at the base and sides than over the vault. Since the specific gravity of the brain tissue is higher than that of the cerebro-spinal fluid, the cerebrum tends to sink towards the base and the fluid to accumulate over the vault; hence probably these differences admit of a simple mechanical explanation. Except under abnormal conditions, the amount of cerebro-spinal fluid between the skull and the cerebral convolutions is so small that from a cast of the cranial cavity we can obtain not only a good picture of the general shape and size of the higher parts of the brain, but also various details as to the convolutionary pattern. This method has been applied with marked success to the determination of the characters of the brain in various fossil lemurs by Dr. Forsyth Major and Professor R. Burckhardt, and Professor Gustav Schwalbe has made a large series of such casts from his craniological collection in Strassburg. The interesting observations by Schwalbe[1] on the arrangement of the 'impressiones digitatæ' and 'juga cerebralia' and their relation to the cerebral convolutions in man, the apes, and various other mammals, have directed special attention to a very interesting field of inquiry. As is well known, the marked prominence at the base of the human skull, separating the anterior from the middle fossa, fits into the deep cleft between the frontal and temporal lobes of the brain, and Schwalbe has shown that this ridge is continued—of course in a much less marked form—along the inner surface of the lateral wall of the skull, so that a cast of the cranial cavity presents a shallow but easily recognised groove corresponding to the portion of the Sylvian fissure of the brain separating the frontal and parietal lobes from the temporal lobe. Further there is a distinct depression for the lodgment of the inferior frontal convolution, and a cast of the middle cranial fossa shows the three external temporal convolutions.

We must now turn to the consideration of the relations of the outer surface of the cranium to its inner surface and to the brain. This question has engaged the attention of experts as well as the 'man in the street' since the time of Gall and Spurzheim, and one might naturally suppose that the last word had been said on the subject. This, however, is far from being the case. All anatomists are agreed that the essential function of the cranium is to form a box for the support and protection of the brain, and it is generally conceded that during the processes of development and growth the form of the cranium is modified in response to the stimulus transmitted to it by the brain. In fact it is brain growth that determines the form of the cranium, and not the skull that moulds the brain into shape. This belief, however, need not be accepted without some reservations. Even the brain may be conceived as being influenced by its immediate environment. There are probably periods of development when the form of the brain is modified by the

[1] 'Ueber die Beziehungen zwischen Innenform und Aussenform des Schädels,' *Deutsches Archiv für klinische Medicin*, 1902.

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resistance offered by its coverings, and there are certainly stages when the brain does not fully occupy the cranial cavity.

At an early period in the phylogeny of the vertebrate skull the structure of the greater part of the cranial wall changes from membranous tissue into cartilage, the portion persisting as membrane being situated near the median dorsal line. In the higher vertebrates the rapid and early expansion of the dorsal part of the fore-brain is so marked that the cartilaginous growth fails to keep pace with it, and more and more of the dorsal wall of the cranium remains membranous, and subsequently ossifies to form membrane bones. Cartilage, though constituting a firmer support to the brain than membrane, does not possess the same capacity of rapid growth and expansion. The head of a young child is relatively large, and its skull is distinguished from that of an adult by the small size of the cartilaginous base of the cranium as compared with the membranous vault. The appearance of top-heaviness in the young skull is gradually obliterated as age advances by the cartilage continuing slowly to grow after the vault has practically ceased to enlarge. These changes in the shape of the cranium are associated with corresponding alterations in that of the brain, and it appears to me that we have here an illustration of how the conditions of skull growth may modify the general form of the brain.

Whatever may be the precise influences that determine skull and brain growth, there can be no doubt but that within certain limits the external form of the cranium serves as a reliable guide to the shape of the brain. Statements such as those by Dr. J. Deniker,[1] 'that the inequalities of the external table of the cranial walls have no relation whatever with the irregularities of the inner table, and still less have anything in common with the configuration of the various parts of the brain,' are of too general and sweeping a character. Indeed, various observers have drawn attention to the fact that in certain regions the outer surface of the skull possesses elevations and depressions which closely correspond to definite fissures and convolutions of the brain. Many years ago Sir William Turner, who was a pioneer in cranio-cerebral topography, found that the prominence on the outer surface of the parietal bone, known to anatomists as the parietal eminence, was situated directly superficial to a convolution of the parietal lobe of the brain, which he consequently very appropriately named 'the convolution of the parietal eminence.' Quite recently Professor G. Schwalbe has shown that the position of the third or inferior frontal convolution is indicated by a prominence on the surface of the cranium in the anterior part of the temple. This area of the brain is of special interest to all students of cerebral anatomy and physiology, since it was the discovery by the illustrious French anthropologist and physician, M. Broca, that the left inferior frontal convolution was the centre for speech, that laid the scientific foundation of our present knowledge of localisation of function in the cerebral cortex. This convolution is well known to be much more highly developed in man than in the anthropoid apes, and the presence of a human cranial speech-bump is usually easily demonstrated. The faculty of speech, however, is such a complicated cerebral function that I would warn the 'new' phrenologist to be cautious in estimating the loquacity of his friends by the degree of prominence of this part of the skull, more particularly as there are other and more reliable methods of observation by which he can estimate this capacity.

In addition to the prominences on the outer surface of the cranium, corresponding to the convolutions of the parietal eminence and the left inferior frontal convolution, the majority of skulls possess a shallow groove marking the position of the Sylvian point and the course of the horizontal limb of the Sylvian fissure. Below these two other shallow oblique grooves indicate the line of the cerebral fissures which divide the outer surface of the temporal lobe into its three convolutions, termed superior, middle, and inferior. Most of these cranial surface markings are partially obscured in the living body by the temporal muscle, but they are of interest as showing that in certain places there is a close correspondence in form between the external surface of the brain and that of the skull. There are,

[1] *The Races of Man*, p. 53.

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however, distinct limitations in the degree to which the various cerebral fissures and convolutions impress the inner surface of the cranial wall, or are represented by inequalities on its outer aspect. Thus over the vault of the cranium the position of the fissure of Rolando and the shape of the cerebral convolutions in the so-called motor area, which lie in relation to this fissure, cannot usually be detected from a cast of the cranial cavity, and are not indicated by depressions or elevations on the surface of the skull, so that surgeons in planning the seats of operations necessary to expose the various motor centres have to rely mainly upon certain linear and angular measurements made from points frequently remote from these centres.

The cranium is not merely a box developed for the support and protection of the brain, and more or less accurately moulded in conformity with the growth of this organ. Its antero-lateral portions afford attachments to the muscles of mastication and support the jaws and teeth, while its posterior part is liable to vary according to the degree of development of the muscles of the nape of the neck. Next to the brain the most important factor in determining cranial form is the condition of the organs of mastication—muscles, jaws, and teeth. There is strong evidence in favour of the view that the evolution of man from microcephaly to macrocephaly has been associated with the passage from a macrodontic to a microdontic condition. The modifications in the form of the cranium due to the influence of the organs of mastication have been exerted almost entirely upon its external table; hence external measurements of the cranium, as guides to the shape of the cranial cavity and indications of brain development, while fairly reliable in the higher races, become less and less so as we examine the skulls of the lower races, of prehistoric man, and of the anthropoid apes.

One of the most important measurements of the cranium is that which determines the relation between its length and breadth and thus divides skulls into long or short, together with an intermediate group neither distinctly dolichocephalic nor brachycephalic. These measurements are expressed by an index in which the length is taken as 100. If the proportion of breadth to length is eighty or upwards, the skull is brachycephalic; if between seventy-five and eighty, mesaticephalic; and below seventy-five, dolichocephalic. Such a measurement is not so simple a matter as it might appear at first sight, and craniologists may themselves be classified into groups according as they have selected the nasion, or depression at the root of the nose, the glabella, or prominence above this depression, and the ophryon, a spot just above this prominence, as the anterior point from which to measure the length. In a young child this measurement would practically be the same whichever of these three points was chosen, and each point would be about the same distance from the brain. With the appearance of the teeth of the second dentition and the enlargement of the jaws the frontal bone in the region of the eyebrows and just above the root of the nose thickens, and its outer table bulges forwards so that it is now no longer parallel with the inner table. Between these tables air cavities gradually extend from the nose, forming the frontal sinuses. Although the existence and significance of these spaces and their influence on the prominence of the eyebrows were the subject of a fierce controversy more than half a century ago between the phrenologists and their opponents, it is only recently that their variations have been carefully investigated.

The frontal sinuses are usually supposed to vary according to the degree of prominence of the glabella and the supra-orbital arches. This, however, is not the case. Thus Schwalbe[1] has figured a skull in which the sinuses do not project as high as the top of the glabella and supra-orbital prominences, and another in which they extend considerably above these projections. Further, Dr. Logan Turner,[2] who has made an extensive investigation into these cavities, has shown that in the aboriginal Australian, in which this region of the skull is unusually prominent, the frontal sinuses are frequently either absent or rudimentary. The ophryon has

[1] 'Studien über Pithecanthropus erectus,' *Zeitschrift für Morphologie und Anthropologie*, Bd. i. 1899.

[2] *The Accessory Sinuses of the Nose*, 1901.

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been selected by some craniologists as the anterior point from which to measure the length of the skull, under the impression that the frontal sinuses do not usually reach above the glabella. Dr. Logan Turner, however, found that out of 174 skulls in which the frontal sinuses were present in 130 the sinuses extended above the ophryon. In seventy-one skulls the depth of the sinus at the level of the ophryon varied from 2 mm. to 16 mm., the average being 5·2 mm., while in the same series of skulls the depth at the glabella varied from 3 mm. to 18 mm., with an average depth of 8·5 mm. It thus appears that the selection of the ophryon in preference to the glabella, as giving a more accurate clue to the length of the brain, is based upon erroneous assumptions, and that neither point can be relied upon in the determination of the anterior limit of the cranial cavity.

The difficulties of estimating the extent of the cranial cavity by external measurements and the fallacies that may result from a reliance upon this method are especially marked in the case of the study of the prehistoric human calvaria, such as the Neanderthal and the Trinil and the skulls of the anthropoid apes.

Statistics are popularly supposed to be capable of proving almost anything, and certainly if you allow craniologists to select their own points from which to measure the length and breadth of the cranium, they will furnish you with tables of measurements showing that one and the same skull is dolichocephalic, mesaticephalic, and brachycephalic. Let us take as an illustration an extreme case, such as the skull of an adult male gorilla. Its glabella and supra-orbital arches will be found to project forwards, its zygomatic arches outwards, and its transverse occipital crests backwards, far beyond the anterior, lateral, and posterior limits of the cranial cavity. These outgrowths are obviously correlated with the enormous development of the muscles of mastication and those of the back of the neck. In a specimen in my possession the greatest length of the cranium, *i.e.*, from glabella to external occipital protuberance, is 195 mm., and the greatest breadth, taken between the outer surfaces of the zygomatic processes of the temporal bone, is 172 mm., giving the marked brachycephalic index of 88·21. The zygomatic processes, however, may reasonably be objected to as indicating the true breadth, and the side wall of the cranium just above the line where the root of this process springs from the squamous portion of the temporal bone will certainly be much nearer the cranial cavity. Measured in this situation the breadth of the cranium is 118 mm., which gives a length-breadth index 60·51, and thus represents the skull as decidedly dolichocephalic. The transverse occipital crests and the point where these meet in the middle line to form the external occipital protuberance are much more prominent in the male than in the female gorilla, and the estimate of the length of the cranium in this male gorilla may be reduced to 160 mm. by selecting the base of the protuberance in place of its posterior extremity as the posterior end measurement. This raises the index to 73·75, and places the skull near the mesaticephalic group. At the anterior part of the skull the prominent glabella is separated from the inner table of the skull by large air sinuses, so that on a median section of the skull the distance from the glabella to the nearest part of the cranial cavity is 36 mm. We have here, therefore, another outgrowth of the cranial wall which in an examination of the external surface of the skull obscures the extent of the cranial cavity. Accordingly the glabella cannot be selected as the anterior point from which to measure the length of the cranium, and must, like the zygomatic arches and occipital protuberance, be excluded from our calculations if we desire to determine a true length-breadth index. The difficulty, however, is to select a definite point on the surface of the cranium to represent its anterior end, which will be free from the objections justly urged against the glabella. Schwalbe suggests the hinder end of the supra-glabellar fossa, which he states often corresponds to the beginning of a more or less distinctly marked frontal crest. I have found this point either difficult to determine or too far back. Thus in my male gorilla the posterior end of this fossa formed by the meeting of the two temporal ridges was 56 mm. behind the glabella, and only 24 mm. from the bregma, while in the female gorilla the temporal ridges do not meet, but there is a low median frontal ridge, which may be considered as bounding posteriorly the supra-glabellar fossa. This point is 22 mm. from the glabella, and between 50 mm. and 60 mm. in front of the bregma.

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I would suggest a spot in the median line of the supra-glabellar fossa which is crossed by a transverse line uniting the posterior borders of the external angular processes of the frontal bone. I admit this plan is not free from objections, but it possesses the advantages of being available for both male and female skulls. In my male skull the selection of this point diminishes the length of the cranial by 25 mm., thus reducing it to 137 mm. The breadth being calculated at 114 mm., the index is 83·21, and hence distinctly brachycephalic. The length of the cranial cavity is 118 mm. and the breadth 96 mm., and the length-breadth index is thus the brachycephalic one of 81·36.

I have given these somewhat detailed references to the measurements of this gorilla's skull because they show in a very clear and obvious manner that from an external examination of the skull one might easily be misled as to the size and form of the cranial cavity, and that, in order to determine from external measurements the proportions of the cranial cavity, skull outgrowths due to other factors than brain growth must be rigorously excluded. Further, these details will serve to emphasise the interesting fact that the gorilla's skull is decidedly brachycephalic. This character is by no means restricted to the gorilla, for it has been clearly proved by Virchow, Schwalbe, and others that all the anthropoid apes are markedly round-headed. Ever since the introduction by the illustrious Swedish anthropologist Anders Retzius of a classification of skulls according to the proportions between their length and breadth great attention has been paid to this peculiarity in different races of mankind. It has been generally held that brachycephaly indicates a higher type of skull than dolichocephaly, and that the increase in the size of the brain in the higher races has tended to produce a brachycephalic skull. When the cranial walls are subject to excessive internal pressure, as in hydrocephalus, the skull tends to become distinctly brachycephalic, as a given extent of wall gives a greater internal cavity in a spherical than an oval form. In estimating the value of this theory as to the evolutionary line upon which the skull has travelled, it is obvious that the brachycephalic character of the skulls of all the anthropoid apes is a fact which requires consideration.

Although an adult male gorilla such as I have selected presents in an extreme degree outgrowths from the cranial wall masking the true form of the cranial cavity, the same condition, though to a less marked extent, is met with in the human subject. Further, it is interesting to note that the length of the skull is more liable to be increased by such growths than the breadth, since they occur especially over the lower part of the forehead and to a less degree at the back of the skull, while the side walls of the cranium in the region of its greatest breadth generally remain thin.

Few if any fossils have attracted an equal amount of attention or given rise to such keen controversies as the 'Neanderthal' and the 'Trinil' skull-caps. According to some authorities both these skull-caps are undoubtedly human, while others hold that the 'Neanderthal' belongs to an extinct species of the genus Homo, and the 'Trinil' is the remains of an extinct genus—*Pithecanthropus erectus* of Dubois—intermediate between man and the anthropoids. One of the most obvious and easily recognised peculiarities of these skull-caps is the very marked prominence of the supra-orbital arches. The glabella-occipital length of the Neanderthal is 204 mm., and the greatest transverse diameter, which is over the parietal region, is 152 mm.—an index of 74·51—while the much smaller Trinil calvaria, with a length of 181 mm. and a breadth of 130 mm., has an index of 71·8. Both of these skulls are therefore slightly dolichocephalic. Schwalbe has corrected these figures by making reductions in their lengths on account of the frontal 'outworks,' so that he estimates the true length-breadth index of the Neanderthal as 80 and that of the Trinil as 75·5. These indices, thus raised about 5 per cent., are considered to represent approximately the length-breadth index of the cranial cavity. A comparison of the external and internal measurements of many recent skulls with prominent glabellæ would, I suspect, show a greater difference than that calculated by Schwalbe for the Neanderthal and Trinil specimens. In a male skull, probably an aboriginal Australian, with a cranial capacity of 1227 c.cm. I found that the glabella-occipital length was

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189 mm., and the transverse diameter at the parieto-squamous suture 127 mm., which gives an index of 67·20 and makes the skull decidedly dolichocephalic. The length of the cranial cavity, however, was 157 mm. and the breadth 121 mm. (an index of 77·07 and a difference of nearly 10 per cent.), so that while from external measurements the skull is distinctly dolichocephalic, the proportions of its cavity are such that it is mesaticephalic. It is probable that many skulls owe their dolichocephalic reputation simply to the prominence of the glabella and supra-orbital ridges. An excessive development of these structures is also liable to give the erroneous impression of a retreating forehead. In the Australian skull just mentioned the thickness of the cranial wall at the glabella was 22 mm.; from this level upwards it gradually thinned until 45 mm. above the glabella it was only 6 mm. thick. When the bisected skull was placed in the horizontal position the anterior surface of the frontal bone sloped from the glabella upwards and distinctly backwards, while the posterior or cerebral surface was inclined upwards and forwards. In fact, the cranial cavity in this region was separated from the lower part of the forehead by a wedge-shaped area having its apex upwards and its base below at the glabella.

The cranial wall opposite the glabella is not appreciably thicker in the Neanderthal calvaria than in the Australian skull to which I have already referred, and the form of the cranial cavity is not more masked by this prominence in the Neanderthal than in many of the existing races.

Although the Neanderthal skull is by no means complete, the base of the cranium and the face bones being absent, still those parts of the cranial wall are preserved that are specially related to the portion of the brain which subserves all the higher mental processes. It includes the frontal, parietal, and upper part of the occipital bones, with parts of the roof of the orbits in front, and of the squamous division of the temporal bones at the sides. On its inner or cranial aspect there are markings by which the boundaries between the cerebrum and the cerebellum can be determined. In a profile view of such a specimen an inio-glabellar line can be drawn which will correspond very closely to the lower boundary of the cerebrum, and indicate a horizontal plane above which the vaulted portion of the skull must have contained nearly the whole of the cerebrum.

Schwalbe[1] has devised a series of measurements to illustrate what he regards as essential differences between the Neanderthal skull-cap and the corresponding portion of the human skull. From the inio-glabellar line another is drawn at right angles to the highest part of the vault, and by comparing the length of these two lines we can determine the length-height index. According to Schwalbe this is 40·4 in the Neanderthal, while the minimum in the human skull is 52. He further shows that the frontal portion of the vault, as represented by a glabella-bregmatic line, forms a smaller angle with the base or inio-glabellar line, and that a vertical line from the posterior end of the frontal bone (bregma) cuts the inio-glabellar further back than in the human subject. Professor King, of Galway, attached special importance to the shape and proportions of the parietal bones, and more particularly to the fact that their mesial borders are shorter than the lower or temporal, whereas the reverse is the case in recent man. This feature is obviously related to the defective expansion of the Neanderthal vault, and Professor Schwalbe also attributes considerable significance to this peculiarity.

Another distinctive feature of the Neanderthal skull is the relation of the orbits to the cranial wall. Schwalbe shows that its brain-case takes a much smaller share in the formation of the roof of the orbit than it does in recent man, and King pointed out that a line from the anterior inferior angle of the external orbital process of the frontal bone, drawn at right angles to the inio-glabellar line, passed in the Neanderthal in front of the cranial cavity, whereas in man such a line would have a considerable portion of the frontal part of the brain-case anterior to it.

[1] 'Ueber die specifischen Merkmale des Neanderthalschädels,' *Verhandl. der anatomischen Gesellschaft in Bonn*, 1901.

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From the combined results of these and other measurements Schwalbe arrives at the very important and interesting conclusion that the Neanderthal skull possesses a number of important peculiarities which differentiate it from the skulls of existing man, and show an approximation towards those of the anthropoid apes. He maintains that in recognising with King [1] and Cope [2] the Neanderthal skull as belonging to a distinct species, Homo Neanderthalensis, he is only following the usual practice of zoologists and palæontologists by whom specific characters are frequently founded upon much less marked differences. He maintains that as the Neanderthal skull stands in many of its characters nearer to the higher anthropoids than to recent man, if the Neanderthal type is to be included under the term *Homo sapiens*, then this species ought to be still more extended, so as to embrace the anthropoids.

It is interesting to turn from a perusal of these opinions recently advanced by Schwalbe to consider the grounds on which Huxley and Turner, about forty years ago, opposed the view, which was then being advocated, that the characters of the Neanderthal skull were so distinct from those of any of the existing races as to justify the recognition of a new species of the genus Homo. Huxley, while admitting that it was 'the most pithecoid of human skulls,' yet holds that it 'is by no means so isolated as it appears to be at first, but forms in reality the extreme term of a series leading gradually from it to the highest and best developed of human crania.' He states that 'it is closely approached by certain Australian skulls, and even more nearly by the skulls of certain ancient people who inhabited Denmark during the stone period.' Turner's [3] observations led him to adopt a similar view to that advanced by Huxley. He compared the Neanderthal calvaria with savage and British crania in the Anatomical Museum of the University of Edinburgh, and found amongst them specimens closely corresponding to the Neanderthal type.

While yielding to no one in my admiration for the thoroughness and ability with which Schwalbe has conducted his elaborate and extensive investigations on this question, I must confess that in my opinion he has not sufficiently recognised the significance of the large cranial capacity of the Neanderthal skull in determining the zoological position of its owner, or made sufficient allowance for the great variations in form which skulls undoubtedly human may present.

The length and breadth of the Neanderthal calvaria are distinctly greater than in many living races, and compensate for its defect in height, so that it was capable of lodging a brain fully equal in volume to that of many existing savage races and at least double that of any anthropoid ape.

A number of the characters upon which Schwalbe relies in differentiating the Neanderthal skull-cap are due to an appreciable extent to the great development of the glabella and supra-orbital arches. Now these processes are well known to present very striking variations in existing human races. They are usually supposed to be developed as buttresses for the purpose of affording support to the large upper jaw and enable it to resist the pressure of the lower jaw due to the contraction of the powerful muscles of mastication. These processes, however, are usually feebly marked in the microcephalic, prognathous, and macrodont negro skull, and may be well developed in the macrocephalic and orthognathous skulls of some of the higher races. Indeed, their variations are too great and their significance too obscure for them to form a basis for the creation of a new species of man. Both Huxley and Turner have shown that the low vault of the Neanderthal calvaria can be closely parallelled by specimens of existing races.

If the characters of the Neanderthal calvaria are so distinctive as to justify the recognition of a new species, a new genus ought to be made for the Trinil skull-cap. In nearly every respect it is distinctly lower in type than the Neanderthal, and yet many of the anatomists who have expressed their opinion on the subject maintain that the Trinil specimen is distinctly human.

[1] 'The Reputed Fossil Man of the Neanderthal,' *Journal of Science*, 1864.
[2] 'The Genealogy of Man,' *The American Naturalist*, vol. xxvii. 1893.
[3] 'The Fossil Skull Controversy,' *Journal of Science*, 1864.

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Important and interesting as are the facts which may be ascertained from a study of a series of skulls regarding the size and form of the brain, it is evident that there are distinct limits to the knowledge to be obtained from this source. Much additional information as to racial characters would undoubtedly be gained had we collections of brains at all corresponding in number and variety with the skulls in our museums. We know that as a rule the brains of the less civilised races are smaller, and the convolutions and fissures simpler, than those of the more cultured nations, beyond this but little more than that definitely determined.

As the results of investigations in human and comparative anatomy, physiology, and pathology, we know that definite areas of the cerebral cortex are connected with the action of definite groups of muscles, and that the nervous impulses starting from the organs of smell, sight, hearing, and common sensibility reach defined cortical fields. All these, however, do not cover more than a third of the convoluted surface of the brain, and the remaining two thirds are still to a large extent a *terra incognita* so far as their precise function is concerned. Is there a definite localisation of special mental qualities or moral tendencies, and if so where are they situated? These are problems of extreme difficulty, but their interest and importance are difficult to exaggerate. In the solution of this problem anthropologists are bound to take an active and important part. When they have collected information as to the relative development of the various parts of the higher brain in all classes of mankind with the same thoroughness with which they have investigated the racial peculiarities of the skull, the question will be within a measurable distance of solution.

The following Papers and Reports were read :—

1. *Skulls from Round Barrows in East Yorkshire.*[1]
By WILLIAM WRIGHT, *M.B., M.Sc., F.R.C.S.*

The skulls upon which these remarks are offered are some eighty in number, and are now in the Mortimer Museum at Driffield. From the fact that the interments closely resemble each other it is inferred that they took place about the same time; from the further fact that primitive articles of bronze have been occasionally met with in the graves, albeit much less frequently than articles of stone and bone, it is assumed that they date back to the Early Bronze age, some of them possibly to the Late Stone age.

As to the skulls almost all the varieties of cranial shape met with in Europe are represented: types so widely different are found as those named by Sergi *Ellipsoides Pelasgicus Longissimus, Sphenoides Latus,* and *Ellipsoides Africus Rotundus.* The cephalic index ranged from 69 to 92. It is doubtful if it is possible to find a materially more mixed series of skulls in a community of to-day. Perhaps the only marked distinction between these prehistoric skulls and those of the present time is to be found in the jaws and teeth, although even here retrograde changes were discoverable such as unerupted and dwarfed wisdom teeth, an absent upper lateral incisor and a lower canine overlapping the adjacent lateral incisor on account of overcrowding of the teeth.

The mandibular and coronoid indices suggested by Professor Arthur Thomson were calculated whenever possible. I found no co-relation between them and skull-shape, but that skulls with similar indices were possessed of different shapes, and *vice versa.*

A marked resemblance was frequently noted between the skulls from any one barrow: so striking was it that one was inclined to attribute it to the barrows having been family burial-grounds. This resemblance was particularly apparent in nine skulls taken from one barrow; four of the nine, moreover, although those of adults, had the metopic suture unclosed. Metopism, when found, occurred in long skulls rather than in broad skulls; a fact which on *a priori* grounds one would perhaps not have expected. Judging from the

[1] To be published in full in the *Journal of the Anthropological Institute,* xxxiv. 1903.

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frequently open sutures and the condition of the teeth, it would appear that the dead here buried had seldom reached an age greater than that of fifty.

In concluding one has no hesitation in stating that Dr. Thurnam's dictum 'round barrow, round skull,' is not even approximately accurate so far as the skulls from the round barrows of Yorkshire are concerned.

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2. *Some Observations on the Pads and Papillary Ridges on the Palm of the Hand.* By E. J. Evatt.

During the course of development of the hand eleven well-defined pads or cushions appear on the palm. The disposition and form of the pads when best marked in the fœtus correspond very closely with that which obtains in certain lower animals (*e.g.*, the mouse), and the pads in both cases are probably morphologically equivalent, and, further, in man's remote ancestors possibly served similar functions. In the adult the pads may be regarded as vestigial.

It is probable that when the hand began to be used as an organ of prehension rather than of locomotion, the deep layer of the epidermis invaded the corium in a fluted form, and in this way the close and complicated papillæ were differentiated. The interlocking of the corium with the epidermis serves probably to strengthen the connection between the two.

The interlocking ridges or deep flutings are at first comparatively simple in their arrangement, and tend to lie transversely to the long axis of the limb, even on the sites of the original pads where the patterns eventually assume most complex forms. Later on, yet long before the ridges appear on the surface, the deep flutings have assumed the patterns characteristic of the adult papillary ridges.

The papillary patterns appear on the surface at about the eighteenth week, and are formed by the intervening epidermal tissue sinking in between the buttress-like processes of the underlying flutings, and they thus come to be the counterpart of the perfected patterns upon which they are moulded.

The convexities of the patterns on the pads of the fingers are directed distally, while the convexities of the patterns over the remaining pads take a proximal direction; that is, in grasping, the convexities are directed in lines of least resistance; it would, therefore, seem probable that as the hand became an organ of prehension the flutings assumed the forms already described as the result of mechanical forces.

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3. *Some Recent Excavations at Hastings, and the Human Remains found.* By J. G. Garson, *M.D.*, *and* W. J. Lewis Abbott.

In this paper a description is given of the geological formation and position of Hastings in relation to certain excavations recently made for the purpose of constructing a passenger-lift from the foreshore to the top of the cliff, in the course of which a number of human remains were found. The date at which these were deposited is uncertain, but they appear to include two racial elements, the earlier of which presented characters agreeing with those typical of the Neolithic race, while the other remains were of people of a much later date.

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4. *Remarks on a Collection of Skulls from the Malay Peninsula.* By Nelson Annandale, *B.A.*

These skulls were obtained by Mr. H. C. Robinson and myself in the Patani States, the population of which is very mixed, consisting partly of so-called Malays and partly of so-called Siamese, the difference between these two peoples being chiefly one of religion. The skulls fall naturally into four groups, one of which, represented by three adult specimens, shows many primitive characters, and is especially remarkable for the great development of the cerebellar part of the

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occiput, agreeing in this character with a series of Orang-Laut skulls from the State of Trang, on the west coast of the Malay Peninsula, which the author has recently described[1] in brief. An interesting feature of the series at present under discussion, and also, so far as can be seen, of the Orang-Laut specimens, is the large proportion of individuals in which the third molar has not developed normally. Though the Malay and Siamese skulls in our collection show certain resemblances to those representing the jungle tribes of the Malay Peninsula, they are separated from them by having a much higher cephalic index and a greater cubic capacity, and by other differences of racial importance.

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5. *Grattan's Craniometer and Craniometric Methods.* *By* Professor J. SYMINGTON, *M.D.*, *F.R.S.*

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6. *Anthropometric Measurements in Crete and other parts of the Ægean Area.* *By* W. L. H. DUCKWORTH, *M.A.*—See Reports, p. 404.

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7. *Report of the Committee on Anthropometric Investigation in Great Britain and Ireland.*—See Reports, p. 389.

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8. *Report of the Committee on a Pigmentation Survey of the School Children of Scotland*—See Reports, p. 415.

FRIDAY, SEPTEMBER 11.

The following Papers and Report were read :—

1. *Palæolithic Implements from the Shelly Gravel Pit at Swanscombe, Kent.* *By* Mrs. C. STOPES.

The late Mr. Stopes on April 27, 1900, discovered in a newly opened section of sand and gravel in a pit at Swanscombe, Kent, many remains of animal mollusca and other fossils interstratified with flint implements of various kinds. The latter included the following varieties: (1) Ordinary axe or hache type; (2) fine smaller, of same shape; (3) broad leaf-shaped type; (4) ovate types; (5) boat-shaped type, pointed at each end; (6) discs; (7) large many-angled projectiles; (8) very fine-pointed stones as awls; (9) worked as if for graving tools; (10) worked as if to clear marrow-bones; (11) scrapers, spokeshaves, and combined stones in all colours and shades of flint and patina—white cream, ochreous, brown, black. Many of them are derived and waterworn, many are glaciated.

As these are associated with a fauna containing many extinct species, Mr. Stopes considered that his discovery pushed back the geological date of man's appearance in the lower Thames valley to a period much earlier than has hitherto been supposed. The pit is now entirely worked out, and the specimens already in hand alone remain to show its contents.

The fossils have been verified by Mr. Kennard and are here given. Those

[1] *Fasciculi Malayenses: Anthropology*, part i.

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marked * are extinct, those marked † are extinct in this country but living on the Continent.

SPECIES.

MAMMALIA.

*Bos primigenius.
†Canis lupus.
Cervus elaphus.
† „ tarandus.
*Elephas antiquus.
* „ primigenius.
Equus caballus.
*Microtus amphibius.
„ agrestis.
„ glareolus.
„ intermedius.
Mus sylvaticus.
*Rhinoceros leptorhinus.
Sus scrofa.
*Trogontherium cuvieri.

AVES.

Anas sp.

REPTILIA.

*Emys sp.
Rana temporaria.
Tropidonotus natrix.

PISCES.

Anguilla anguilla.
Esox lucius.
Leuciscus rutilus.
* „ sp.
Tinca vulgaris.

PLANTS.

Chara sp.

MOLLUSCA.

Agriolimax agrestis.
Carychium minimum.
Pyramidula rotundata.
† „ ruderata.
Helicella caperata.
Helix nemoralis.
Helicigona arbustorum.
Cochlicopa lubrica.
Limnæa auricularia.
„ palustris.
„ peregra.
„ truncatula.
„ stagnalis.
Hygromia granulata.
„ hispida.
Vallonia pulchella.
Vitrea radiatula.
„ crystallina.
„ nitida.
„ nitidula.
Azeca tridens.
Pupa muscorum.
Cæcilianella acicula.
Vertigo antivertigo.
Clausilia laminata.
„ perversa.
Succinea elegans.
Ancylus fluviatilis.
Planorbis albus.
„ carinatus.
„ contortus.
„ cornneus.
„ glaber.
„ marginatus.
„ nautilens.
„ fontanus.
† „ vortioulus.
Paludestrina ventrosa.
Bithynia tentaculata.
„ leachii.
Vivipara clactonensis.
Valvata cristata.
„ piscinalis.
*Neritina grateloupiana
†Unio littoralis.
„ pictorum.
„ tumidus.
†Corbicula fluminalis.
Sphærium corneum.
Pisidium amnicum.
* „ astartoides.
„ fontinale.
„ pusillum.
† „ supinum.

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2. *Saw-edged Palæoliths.* *By* Mrs. C. STOPES.

Among the stones collected by Mr. Stopes during the last two years of his life, and left by him at Swanscombe, are a beautiful series of saw-edged palæolithic flakes and implements from the Craylands gravel pit at Swanscombe. The roughnesses are not the result of accident or use, but are intentional serration, generally on a straight edge, though sometimes continued into the spokeshaves and scrapers so frequently combined in the *multum in parvo* implements of the period.

At the York meeting of the British Association, 1881, when Mr. Stopes brought forward his carved *Pectunculus* from the Red Crag, as the first recorded

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trace of Pliocene man, Professor Prestwich stated in the discussion that he had found a bone in the same series which seemed to have been sawn into two. But as he had thought it was impossible that man should have existed at that period, he had pronounced against the saws. Here, however, are both saws and men associated in the pre-glacial stratified deposits of the early Pleistocene period, and it is quite possible that they may yet be found in Pliocene times.

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3. *The Survival of Primitive Implements in the Faroes and Iceland.*[1]

By NELSON ANNANDALE, *B.A.*

The objects noticed were collected by the author in the Faroes, the Westmann Isles, and the Rangarval district of South Iceland. They were in use at the end of the nineteenth century, though mostly obsolescent, and include stone hammers of two different kinds, bone needles, pliers, skates (or rather runners), pegs for stretching out hides, toys, sieves of skin, and other articles. Their distribution in the districts indicated is by no means uniform, those which occur in the Faroes being generally absent from Iceland, and *vice versa*, while those from the Westmann Isles differ from the specimens collected on the mainland opposite. This difference in distribution may be partially due to differences in local conditions that have caused some implements to disappear and others to continue in use, but may also have some ethnological interest, it being very improbable that the people of the Faroes are of even as pure Scandinavian descent as those of Iceland, while the Westmann Islanders did not originally come from Rangarval, but from the extreme north of Iceland, where the population is more highly cultured than that of the south.

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4. *Coldrum, Kent, and its relation to Stonehenge.*[2]

By GEORGE CLINCH.

The district which lies immediately to the N.W. of Maidstone is remarkable for an interesting series of prehistoric megalithic remains. The best known of these is Kits Coty House; a fallen cromlech called the 'Countless Stones,' lower down the same hillside; several other ruined examples in Addington Park; and Coldrum, or Coldreham, which stands less than two miles north of this, on high ground overlooking the Medway valley and within sight of Kits Coty House.

The remains of Coldrum comprise a central cromlech without capstone, an irregular line of large blocks of stone on the western side, and traces of a tumulus. The published descriptions of it[3] do not, however, mention its most important and characteristic feature, namely, that between the two upright stones which form the sides of the chamber there stand two stones, about midway, forming a partition which divides the space into two adjoining sepulchral chambers.

The size of the upright stones is remarkable (7 feet high by 11 feet by 2 feet 3 inches thick), and still more the regularity of their form.

Seventeen irregularly placed stones, inclosing a small space on the W. side of the cromlech, represent a part only of what was probably a quadrangular or oblong enclosure, placed at the foot of the tumulus, by which the whole cromlech was originally concealed.

The arrangements above described—of a two-chambered cromlech with a square or oblong tumulus and massive outline wall—are of great rarity; and the whole structure suggests a late date in the neolithic age, when the form of the sepulchral chambers was followed out in the construction of the mound. A similar somewhat larger neolithic megalithic structure at Sievern, in Hanover, has been fully published, with illustrations, by Fr. Tewes.[4]

[1] To be published in full in *Journ. Anthr. Inst.* xxxiii.

[2] Published in full in *Man*, 1904, 12.

[3] Flinders Petrie, *Archæologia Cantiana*, vol. xiii. pp. 14, 16; George Payne, *Collectanea Cantiana* (1893), pp. 139–141.

[4] *Die Steingräber der Provinz Hannover*, 1898.

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The regular form, good proportions, and flat surfaces of the upright stones at Coldrum are very remarkable, and suggest artificial shaping and perhaps dressing. These also point to a late period in the neolithic age, and present remarkable similarities to the forms at Stonehenge. That these careful forms and surfaces could be produced with stone tools has been shown in the case of Stonehenge by Professor Gowland, 'Recent Excavations at Stonehenge.'[1]

The idea of enclosing the principal structure within a line of stones is also common to Stonehenge and Coldrum; but whereas Coldrum was obviously a sepulchral monument, Stonehenge, though following to some extent the same arrangement, was conceived on a more ambitious scale, and probably designed for a very different purpose.

The megalithic structures of Kent furnish a valuable series illustrative of the constructive skill of neolithic man. At Kits Coty House the two main uprights lean somewhat inwards and rest against the middle upright between them, thus distributing the weight of the capstone so as to consolidate the whole structure, the resistance of which to complete denudation proves also the excellence of its foundations. At Coldrum the construction has developed further, for the uprights still stand erect, even though no capstone remains.

The author traces in these rectangular megalithic monuments the prototypes of the series of Anglo-Saxon churches, sometimes called 'Scottish,' 'Celtic,' or 'British,' of which good examples are seen at Boarhurst, Hants, and in Dover Castle.

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5. *Excavations at Caerwent, Monmouthshire*, 1899–1903.[2]

By T. Ashby, jun., *M.A.*

The Romano-British city of Venta Silurum, the site of which is now occupied by the village of Caerwent, Monmouthshire, five miles west of Chepstow and eleven miles east of Newport, is only mentioned by this name in the Antonine Itinerary and by the Geographer of Ravenna. In the former it appears as a station upon the Roman road from London *viâ* Bath to South Wales. In the classical authors it is not spoken of, though the tribe of the Silures is mentioned by Tacitus; but an inscription recently discovered in the centre of the city shows that it was the centre of the tribal organisation under which the Silures lived in Roman times. The text is as follows: . . . *leg(ato) leg(ionis) ii aug(ustæ) proconsul(i) provinc(iæ) Narbonensis leg(ato) Aug(usti) pr(o) pr(ætore) provinc(iæ) Lugudunen(sis) ex decreto ordinis respubl(ica) civit(atis) Silurum.*

The external walls of the city are still clearly traceable. They form a rectangle of about 500 (E. to W.) by 400 (N. to S.) yards, and on the south side are preserved to a height of some 20 feet. Some remains of the east and west gates still exist, while the north gate is preserved up to the spring of the arch, and shows signs of modification. Within the wall and parallel to it a mound of hard clay has been discovered in many places, which is believed to have been the original fortification of the city; whether its origin is military or civil is a point as yet uncertain.

Excavations are still in progress, and, if circumstances permit, may be carried on for several years more, as the greater part of the site is unoccupied by buildings.

The ancient city appears, at one period of its existence at any rate, to have been divided into twenty insulæ. The modern highway, which runs from east to west through the centre of the site, follows the line of the ancient road; and at almost equal distances north and south of this ancient roads have been brought to light. There seem to have been four roads running from north to south, of which the easternmost alone has not yet been discovered in any part of its course. It is obvious, however, that our statements on this point must be subject to reserve, inasmuch as much further excavation remains to be done.

The buildings which have been brought to light consist chiefly of private

[1] *Archæologia*, vol. lviii. pp. 37–118.

[2] Full reports in *Archæologia* and summary in *Man*, 1904.

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houses, and some of these present a ground plan which appears to be unique in England, having the rooms arranged round all the four sides of a rectangular courtyard. The walls are strongly built of blocks of limestone, and in some cases the painted plaster upon the walls is found *in situ* in good preservation. Some interesting mosaic pavements have been found.

A large building near the North Gate (so far only partially excavated) may have had some public character, and a little to the east of this gate an amphitheatre (apparently of late date) has recently been discovered *within* the city walls. So little of it is preserved that it must be supposed to have been mainly of wood; the arena wall, which exists almost in its entirety, encloses an oval the diameters of which are about 145 and 125 feet.

The smaller objects include a roughly sculptured head in sandstone, probably of some deity, while pottery, bronze and iron objects, &c. are found in profusion. Some of the coloured enamel is especially good.

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6. *Ribchester: the Roman Fortress Bremetennacum.*

By JOHN GARSTANG, *B.Litt.*

Ribchester, on the Ribble Valley, has long been known. Roman remains, some of them exceptional in character, have been found there since the beginning of archæological record. One object in particular, a bronze ornamental helmet, the head probably of a deity, now preserved in the British Museum, is specially noteworthy. The fame of this Roman station has been increased by an old tradition of buried treasure, which seems to have been based actually upon an event of post-Roman date, and has been shown recently by a distinguished numismatist to have probable reference to the Cuerdale hoard of Saxon coins.

Excavations made in 1898–99 have now shown that the station at Ribchester conformed with the general scheme of frontier defences of the Roman Empire. It was one of a series of such fortresses in methodical arrangement which with the wall of Hadrian formed the northern frontier defences of Roman Britain against the hill tribes of the north. It is analogous in plan and constructive details with other forts of the same system and period. It is to be distinguished primarily from the camps of a moving army the disposition of which is well known from literary sources, just as the name *castellum* is different from the word *castra*. Latin historians were careful of this distinction, and it behoves English archæologists to be equally on their guard. The Roman fort is hardly treated in contemporary literature, but its character and military organisation are now clearly defined by the results of archæological research. This fort is to be distinguished secondarily with the class of which it is an example from the later type of Roman fortress, familiar from ruins on the south-eastern coast line, built in the fourth century to oppose the dangers which threatened the Saxon shore. These later strongholds have external buttresses and turrets, are generally larger and with higher walls, and exhibit the prototypes of some of the mediæval details of fortification.

But the class of fortress to which Ribchester belongs is entirely of the earlier character, severe rectangular shapes with internal buttresses and mural towers, magnificent double-arched gates, a stout wall not very high, with parapet and guard chambers upon its length. In large examples of this class, of which Ribchester is one, the interior was filled with stone-built barrack-rooms and stables, arranged regularly in rows and streets. In the centre was the large 'prætorium,' the headquarters of the commander of the division which constituted the garrison. On one side was commonly a large storehouse or granary, and at Ribchester (quite exceptionally) there seems to have been a temple within the walls. Another sub-class of this period is found to be of smaller area—about three acres only—with the outer walls and prætorium only of stone.

The inception of the idea of a series of frontier fortresses in the north was due to Agricola, but the scheme elaborated to its perfection with Hadrian, and much activity in building is still evidenced from the inscriptions under the Antonines.

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It was about this period probably that Bremetennacum was finally built. There is no definite evidence of its earlier origins, but it is known that a detachment of the Sixth Legion (from York) completed some building work under Calpurnius Agricola in the middle of the second century. It was garrisoned at one time by a wing of Sarmatian cavalry (auxiliaries), and later by a body of Asturians. It was connected in the military scheme by roads into the Roman stations at Manchester (Mancunium) and at Wigan (Coccium) to the south, with Overborough (Galacum) and Lancaster (? Rigodunum) to the north, and directly with the legionary headquarters at York (Eboracum) by the road over the hills through Ilkley (? Olicana).

[A full description of the excavations and recent discoveries is given in the excursion handbook for the Southport meeting.]

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7. *The Roman Fort at Brough.* *By* JOHN GARSTANG, *B.Litt.*

Excavations of an exploratory character have been made during the past month upon the Roman site at Brough, in Derbyshire, near to Hope village and station. They have shown that the station there was military, being in fact a fortress of the earlier class, built probably under Hadrian or Antoninus Pius, in the earlier half of the second century. It corresponds in many particulars to the type of forts along the wall; though small in area it was stoutly built. Its outer walls were nowhere less than six feet in thickness, and its prætorium was extensive, with a remarkable strength of masonry. It had the usual four gateways and rounded corners surmounted by turrets, and it was situated in the favourite position at the junction of two streams. The outline of the fortress, the position of the prætorium and adjoining buildings, and the suggestion of other stone buildings within the enclosure have been determined by these experimental excavations. In a central position, possibly within the prætorium itself, was disclosed a deep-walled enclosure, with steps leading down from top to bottom. The masonry is characteristically solid. In clearing out the refuse from this there were found, among other remains, two inscribed altars, difficult to read, the one small and well carved but broken, the other large and complete. Of more immediate interest were portions of a large inscribed tablet which when put together proved to have been about five feet in length, with a nice moulded border. The inscription dates from the time of Antoninus Pius, and seems to have been set up by a præfect of the First Cohort of Aquitani under Julius Verus, then Governor of Britain. The name of the præfect appears to be new, but the contingent is known from monuments found near Bakewell and elsewhere.

The Council of the Derbyshire Archæological Society are encouraged by these tentative results to make a careful and systematic excavation of the whole site, and cordially invite general interest and support. The inception of the scheme is due to Mr. W. J. Andrew, F.S.A., editor of the Society's journal, in which the full account of the present and future discoveries will be published from year to year.

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8. *Report of the Committee on the Silchester Excavations.*
See Reports, p. 412.

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9. *On a Prehistoric Drinking-vessel found near Burnley.*
By TATTERSALL WILLIAMSON.

The author described a number of urns found at Todmorden. The urns, which are hand-made, are associated with a flint arrowhead, showing very fine workmanship, a bronze fibula, a pin, and a number of jet and bone beads. In the central cinerary urn, which was of a finer character, were found human remains, and also an incense-cup and a food-vessel; a microscopical examination of the latter showed traces of its former contents.

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In other excavations in the neighbourhood the remains of two persons had invariably been found together, one an adult, the other a child. The author assigned the prehistoric sites near Burnley to three distinct periods, that of the barrows, followed by the epochs of the Earth Circle and the Stone Circle. The period of the barrows would appear to be the earliest, as the barrows—unlike those in Yorkshire, explored by Canon Greenwell—had never, as far as the author knew, been found to contain *bronze* objects.

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10. *Antiquities near Kharga in the Great Oasis.* *By* CHARLES S. MYERS, *M.D.*

The photographs illustrating these antiquities were for the most part taken by the late Anthony Wilkin, who accompanied the writer on his visit to the Great Oasis in 1901.

(i.) At the eastern entrance to the oasis is a large buttressed fortlike ruin, called by the natives El Deir, *i.e.* the monastery. Its walls have a thickness of twelve feet, it covers about a hundred and ninety square feet. The neighbourhood abounds in worked flint implements.

(ii.) On a rising piece of ground about three miles north of the village of Kharga stands the early Christian (Nestorian) necropolis, now called El Baguat. It consists of streets of well-preserved tombs and funereal chapels of unburnt bricks, formerly faced with plaster. Remains of mummy cloths can be seen. Niches are built into the walls, probably to receive lamps and gifts of food for the dead. The interiors of the tombs are decorated with the Egyptian *ankh*, birds, vine-tendrils, &c. There is a large chapel and a tomb covered with frescoes of Biblical scenes, photographs of which are exhibited. The buildings may be attributed approximately to the seventh century.

(iii.) Somewhat nearer Kharga stands the well-preserved temple of Hibis, begun by Darius I. and completed by Darius II., one of the most important monuments of the Persian dynasty in Egypt.

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11. *Egyptian Burial Customs.*[1] *By* JOHN GARSTANG, *B.Litt.*

Excavations made during the past winter upon the hillside at Beni-Hasan, in Upper Egypt, have resulted in the discovery of a necropolis of the Middle Empire, about 2200 B.C., which has thrown much light upon the burial customs of that period. Visitors to the well-known rock-hewn tombs of the princes and great officials are familiar with the paintings of barques and offerings and general funereal furniture upon the walls. These newly found tombs are the burying-places of the minor officials and distinguished women, the middle classes of the locality. They are not sufficiently large, for the most part, nor of suitable character, for mural decorations; but they were found furnished with numerous wooden models, which explain at once many points of interest connected with the burying of the dead, and in themselves illustrate the industrial processes of the ancient country.

Altogether 492 tombs were found and examined. Many of these had never previously been disturbed. Fortunately, too, in several instances the preservation of the objects was perfect. They were seen, as the door of each tomb was opened —boats under sail, funereal barques, granaries, men with oxen, women with geese, brewers and bakers—all in their places, freshly painted and free from dust or accumulation, exactly as they had been left four thousand years ago. A series of photographic views of the interiors, taken by reflected light, illustrate the whole process of the excavation, and these observations, stage by stage, as well as pictures of the deposited objects themselves.

A comparison of results obtained from the several well-furnished tombs shows that there was some uniformity as to the character of the objects that furnished

[1] To be published more fully in *Man*, 1904.

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the houses of the dead. They included essentially the following characters: (*a*) a rowing-boat; (*b*) a sailing-boat; (*c*) a granary; (*d*) a bakery; (*e*) a brewery; (*f*) an ox, or sacrifice; (*g*) a girl with geese and basket. The groups varied slightly, but these were uniformly included. They seem to have borne no relation to the profession of the deceased, but are simply of religious motive—the elaborate provision for a future journey. In one case two other vessels were deposited, but they were of warlike character, and in this case probably had a special significance. In them were armed men, shields, spears, and an interesting group of two figures playing chess.

Numerous small objects were discovered, among them a small wooden statuette of a woman carrying her babe in a shawl upon her back. She is characteristically Libyan. The photographs number about 450, and arrangements are being made for their publication.

MONDAY, SEPTEMBER 14.

The following Report and Papers were read:—

1. *Report of the Committee on the Psychology and Sociology of the Todas.* See Reports, p. 415.

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2. *Toda Kinship and Marriage.* *By* W. H. R. Rivers, *M.D.*

The kinship system and marriage institutions of the Todas were studied by means of the genealogical method.[1] The Todas preserve their pedigrees by oral transmission for several generations, but considerable difficulty was experienced in obtaining the record owing to the existence of a taboo on the names of dead relatives.

Finally, however, a fairly complete genealogical record of the whole community was obtained, going back for two or three generations, and this furnished the basis for the study of the social organisation.

The system of kinship is of the kind known as 'classificatory,' every male of an individual's clan being either his grandfather, father, brother, son, or grandson and every female his grandmother, mother, sister, daughter, or granddaughter. A special feature of the system is that the father-in-law receives the same name as the mother's brother, and the mother-in-law the same name as the father's sister. The orthodox Toda marriage is one between the children of brother and sister: a man marries normally the daughter of his maternal uncle, or of his paternal aunt: and this custom, which is common in Southern India, has so influenced the system of kinship that both mother's brother and wife's father receive the same name, even when the two relations are not united in the same person.

There are two distinct sets of kinship terms: one set used when speaking of a person, and the other used in direct address. The latter terms are more limited in number than the former, and are used in a more general way, and the names of this kind given by individuals to one another are determined largely by the respective generations and relative ages of the speakers.

Although the Toda system is definitely of the classificatory kind, the people often used terms which define more exactly the nature of the relationship; thus, a man might speak of his nephew as 'my son,' or as 'my younger brother's son.' This and other similar practices seem to show that the Toda system is losing its purely classificatory character, and is approaching the descriptive stage.

The Todas have very definite marriage regulations. The people are divided into two endogamous groups, each of which is subdivided into a number of exogamous groups which may be called 'clans.'

The two chief groups are not allowed to intermarry: a man must marry a woman of his own division. The clans into which the two chief divisions are sub-

[1] *Journ. Anthrop. Inst.* xxxi. 1900, p. 74.

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divided take their names from certain important villages. The people of a clan are known as *madol* (village people), and a man is not allowed to marry one of his own *madol*.

Marriage is also regulated by kinship. A man may not marry the daughter of his father's brother. As there is paternal descent, she would be of his own clan. He is also prohibited from marrying the children of his mother's sisters, though they will usually not be members of his clan. There is thus a prohibition of marriages between the children of brothers on the one hand and between the children of sisters on the other hand. Between the children of brother and sister there is not only no such prohibition, but the orthodox marriage is of this kind. A man normally marries the daughter of his mother's brother or of his father's sister. Infant marriage is a well-established Toda custom, and children married to one another are very often cousins—the children of brother and sister. There is, however, a very general custom of transferring wives from one man to another (or from one set of men to another), and the unions which ensue are not necessarily examples of the marriage of cousins.

The Todas have long been noted as a polyandrous people, and the institution of polyandry is still in full working order among them. When a girl becomes the wife of a boy it is usually understood that she becomes also the wife of his brothers.

In nearly every case at the present time and in recent generations the husbands of a woman are own brothers. In a few cases though not brothers they are of the same clan. Very rarely do they belong to different clans.

One of the most interesting features of Toda polyandry is the method by which it is arranged who shall be regarded as the father of a child. For all social and legal purposes the father of a child is the man who performs a certain ceremony about the seventh month of pregnancy, in which an imitation bow and arrow is given to the woman.

When the husbands are own brothers the eldest brother usually gives the bow and arrow, and is the father of the child, though so long as the brothers live together the other brothers are also regarded as fathers.

It is in the cases in which the husbands are not own brothers that the ceremony often becomes of real social importance. In these cases it is arranged that one of the husbands shall give the bow and arrow, and this man is the father, not only of the child born shortly afterwards, but also of all succeeding children, till another husband performs the essential ceremony. Fatherhood is determined so absolutely by this ceremony that a man who has been dead for several years is regarded as the father of any children borne by his widow if no other man has given the bow and arrow.

There is no doubt that in former times the polyandry of the Todas was associated with female infanticide, and it is probable that the latter custom still exists to some extent, through strenuously denied. There is reason to believe that women are now more plentiful than formerly, though they are still in a distinct minority. Any increase, however, in the number of women does not appear to have led to any great diminution of polyandrous marriages, but polyandry is often combined with polygyny. Two or more brothers may have two or more wives in common. In such marriages, however, it seems to be a growing custom that one brother should give the bow and arrow to one wife, and another brother to another wife. It seems possible that the Todas are moving from polyandry towards monogamy through an intermediate stage of combined polyandry and polygyny.

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3. *The Toda Dairy.* *By* W. H. R. Rivers, *M.D.*

The Todas of the Nilgiri Hills practise an elaborate religious ritual which is a development of the ordinary operations of the dairy. The dairy is the temple and the dairyman is the priest.

There are several kinds of dairy-temple, of different degrees of sanctity, corresponding to the different degrees of sanctity of the buffaloes tended at each.

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Of these dairies there are three chief grades. The highest kind is found in secluded spots far from any place where ordinary people live. These dairies belong to one of the two chief divisions of the Todas, the *Tārtharol*, but are tended by men belonging to the other division, the *Teivaliol*. The lowest grade of dairy is found at the villages where the people live, and these dairies are tended by men of the same division as that to which the dairy belongs. The dairies of intermediate sanctity are found only at the villages of the *Tārtharol*, but are tended by members either of the *Teivaliol* or of one special clan of the *Tārtharol*.

It is only the milk of the different kinds of sacred buffalo which is churned in the dairy-temple. There are buffaloes which are not sacred, and their milk is churned in the front part of the huts in which the people live.

The more sacred the dairy, the more elaborate is its ritual. In every one the dairy vessels are divided into two groups. The more sacred vessels are those which come into contact with the buffaloes or the milk. The less sacred are those which receive the products of the churning. In the highest kind of dairy the products of the churning do not pass directly from the more sacred to the less sacred vessels, but have to pass from one to the other by the help of an intermediate vessel. The dairy ritual is accompanied by definite prayer; and the more sacred the dairy, prayer becomes a more prominent feature of the ritual.

In most of the more sacred dairies there is a bell which is an object of reverence, and usually milk is put on this bell during the dairy operations.

The more sacred the dairy, the more is the life of the dairyman hedged about with restrictions. There are definite ordination ceremonies for each grade of office. In the lowest grade they may be completed in less than an hour; in the highest they are prolonged over more than a week.

In addition to the three chief grades of dairy, there are certain dairies in which the ritual has developed in some special direction, and there are often considerable differences in the ritual of different dairies of the same kind, especially of the highest grade. Each clan has a special prayer for use in the dairies belonging to that clan, and each of the highest kinds of dairy has also its own special prayer.

Various features of the lives of the buffaloes are made the occasion of ceremonies, often elaborate and prolonged. Whenever the buffaloes go from one dairy to another to obtain fresh pasturage, the journey becomes an elaborate ceremony which may be prolonged over two or three days. Giving salt to the buffaloes is similarly accompanied by complicated ceremonies, and ceremonies are held fifteen days after the birth of a female calf.

One of the most interesting of the ceremonies of the dairy is connected with the custom of adding buttermilk from a previous churning to the newly drawn milk. By means of the addition of buttermilk, which is called *pep*, a kind of continuity is kept up in the dairy operations; but under certain conditions this continuity is broken, and it becomes necessary to make new *pep*, and this may be the occasion of prolonged and elaborate ceremonies.

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4. *The Ancient Monuments of Northern Honduras and the adjacent parts of Yucatan and Guatemala, with some Account of the Former Civilization of these Regions and the Characteristics of the Races now inhabiting them.*[1] *By* Dr. T. W. Gann.

The author describes

(1) *The Ancient Monuments of Honduras*, namely—

(a) *Temples*: their number at present known and their situation. A typical specimen is described and resemblances are noted to similar structures elsewhere.

(b) *Buildings within mounds*, with stucco-ornamented walls and burial cysts or large burial chambers; some mounds contain more than one chamber.

[1] To be published in full in *Journ. Anthr. Inst.*

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(c) *Stellæ*, sculptured and plain. Similar monoliths occur in Spanish Honduras and Mexico.

(d) *Stone-faced pyramids*, single and in groups. A large stone-faced plateau covered with pyramids has been discovered recently.

(e) *Fortifications*, especially groups of fortified mounds along the sea-shore, and look-out mounds with fortifications attached, near ancient village sites.

(f) *Ovoid underground chambers*: their distribution, size, contents, and probable uses. Similar chambers occur elsewhere.

(2) *The Former Civilisation of Honduras*:—

(a) *Weapons and tools* and the materials from which manufactured. The author notes the unaccountable absence of metals and describes the spear and arrow heads, celts, knives, even grinders, loom-weights, net-sinkers, hammer-stones, scrapers, henequen-cleaners, and other stones of unknown use.

(b) *Ornamental and ceremonial objects*: head-dress ornaments, earrings, nose ornaments, labrets, gorgets, and curiously shaped flint and obsidian objects, probably ceremonial.

(c) *Pottery*.—There are three main varieties: (1) fine thin ware, painted in various colours and glazed; (2) coarser red ware; (3) very clumsy, coarse, unglazed ware, usually employed for sepulchral purposes.

(d) *Burial customs*.—There is great variety in the methods of burial: cremation and partial cremation; burial in cysts and oval chambers; earth burial. The position of corpse and the objects buried with the dead are noted, and also the local custom of burying small animal effigies with the dead.

(e) *Writing and pictographic records* are similar to those found at Palenque, Quiriqua, Chichen-Itza, &c. There is no satisfactory key as yet. Specimens are on stone, pottery, and stucco.

(f) *Religion*.—The Toltec pantheon is described; the probable introduction of human sacrifice is discussed, and ancient religious rites are noted, which are still carried out by remote tribes.

(3) *The Present Inhabitants of Honduras*:—

(a) *Personal characteristics*.—General appearance of males and females; height and development; mental development; influence of diet and environment; family ties and indifference to death.

(b) *Language*.—Maya is practically universal, except amongst the Caribs and a few isolated individuals recently discovered. The author describes the dialects of Maya, the variation in language since the conquest, and the introduction into Maya of Spanish words.

(c) *Religions*.—Christianity, semi-Christianity, idolatry. The author notes the similarity of the ancient religion to Christianity.

(d) *Native arts and agriculture*.—Spinning, weaving, pottery manufacture, black wax candles and ornaments, flint chipping, milpa-making, preparing corn, henequen.

(e) *The influence of civilisation* has been disastrous from the earliest days; the reluctance of Indians to mix with whites or negroes; the influence of alcohol; epidemic and other diseases; with a civilised Indian.

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5. *The Progress of Islâm in India*.[1] *By* WILLIAM CROOKE, *B.A.*

This paper discusses the question whether Islâm is or is not increasing its numbers in India. Various views have been expressed on this point. The reports of the recent and former censuses enable the question to be finally settled. There is no doubt that in certain parts of the country the rise of Islâm in recent years has gone on at a rate higher than that of Hinduism.

[1] To be published in full in *Journ. Anthr. Inst.*

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This increase can be due only to one or both of the following causes:—

1. That there has been a considerable conversion of Hindus to Islâm, and that a regular propaganda has been at work in this direction.

2. That there are causes at work among Muhammadans themselves which tend to produce a higher rate of fertility among them.

As to the first suggestion, there is certainly some conversion of low-caste Hindus to Islâm, due to the fact that the convert acquires a higher social position, and frees himself from the degradation which inevitably attaches to his being a member of a degraded caste. But the result of recent inquiries tends to negative the theory that there is any well-defined missionary propaganda at work among the Indian Muhammadans. On the other hand the action of some of the reformed sects which have been produced among Muhammadans in recent years requires examination.

As to the second suggested cause there is some evidence that physical causes tend to make the Muhammadan more fertile and more long-lived than the Hindu. The former have been recruited from a more vigorous race, such as the Arab and the Central Indian tribes. They discourage infant marriage and the celibacy of widows. They permit a more varied and invigorating diet, particularly as regards the use of meat.

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6. *The Ethnology of Early Italy and its Linguistic Relations to that of Britain.*[1] *By* Professor R. Seymour Conway, *Litt.D.*

The general body of scholars and historical students know so little of the scanty and obscure remains of the Italic dialects, that is, of the languages akin to Latin spoken in Italy before the extension of the Roman dominion over the peninsula, that no one has yet felt surprised at their geographical distribution. Yet a glance at the map of their territories will show that it demands explanation. There are practically only three dialects: 1, Latinian (*i.e.* Latin and Sabine); 2, Oscan; 3, Umbro-Volscian, though the distance between their areas has deterred scholars from classing Umbrian and Volscian together in spite of the complete identity of their characteristics in the inscriptions. How then did they become geographically separate, and how did Latinian wedge itself in between the areas of so many other idioms? There must be some historical causes behind these curious phenomena.

Some clue to the answer is to be found in a set of facts not hitherto observed, viz., the use of different suffixes by different tribes to form their ethnica, *i.e.* the names of communities derived from names of places in their respective district.

There are only six or seven suffixes used for this purpose in ancient Italy: of these three only (for various reasons) are significant for ethnology—viz. -CO-, -NO-, and -TI- (generally -ATI-).

i. The ethnica in -CO-, like *Volsci*, *Hernici*, *Osci*, are all, save for a small batch in Umbria, confined to the plain country along the west coast, and all occur in marshy districts. The word *Volsci* means 'marshmen.' Further, there are some ethnica in -CINI, *i.e.* with -NO- superimposed on -CO-, the result of a conquest by some -NO- folk, all in similar districts. Since Etruscan is not an Indo-European speech, the names *Etrusci*, *Tusci*, *Falisci*, though denoting Etruscans, must have been made by the -CO- folk, who are clearly Indo-European. *Volsci* contains the same stem as Gr. ἕλος, *O(p)sci* that of Lat. *opus*.

ii. The -NO- ethnicon is extremely common throughout Italy, but its frequency in comparison with the others varies remarkably in the different districts; in that of the Hirpini they number[2] 92 per cent. of the known ethnica, in Latium proper only 52 per cent., in Umbria only 31 per cent. If, then, as there is reason to believe, this suffix marks a particular race at a particular epoch, this race was

[1] Published in fullin *Rivista d'Italia* (1903, Agosto) under the title 'I due strati della popolazione indo-europea dell' Italia antica.'

[2] These statistics are based on the collections of the place-names of ancient Italy, given for each of the dialectal areas in my *Italic Dialects* (Camb. Univ. Press, 1897).

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probably most completely master of the soil in the Hirpine district, and most mingled with others in Umbria, at that epoch or later.

Now it is clear that this suffix was the one natural to the Romans, who used it not merely in their own names (*Romani, Latini*, &c.), but also to form names, after the Roman fashion, for the peoples they conquered in Italy or abroad: the Νεαπολῖται became *Neapolitani*, the Σπαρτιᾶται became *Spartani*, and so on. But this suffix was not used by Romans only; the Campanians of Nola called themselves *Novlanos*, and in fact the suffix, as we have seen in the case of the *Hirpini*, was spread over the whole area in which the dialect called Oscan was spoken, as well as being common in the Latinian districts.

iii. The suffix -(A)TI- is enormously more frequent in the -CO- districts than elsewhere, though not entirely confined to them. In Umbria it forms nearly 60 per cent. of the known ethnica, and here it has been superimposed upon -NO-, the *Iguvini* becoming later on *Iguvinates*, &c. It seems to mark the -CO- people at a later epoch.

Combining these data with further linguistic evidence, with that of tradition and of archæological excavations, we can demonstrate—

i. That the -CO- folk inhabited Central Italy before the invasion of the (Asiatic) Etruscans and became their subject-allies. There is evidence that they were ignorant of iron, buried their dead, and differed in other ways from the -NO-folk, *e.g.* by counting kinship through the mother (Professor Ridgeway).

ii. That the -NO- folk were descending into Italy from the Alps (*Val Sabbia*) when their progress was interrupted by the Etruscans, who with their subjects cut off the *Romani* and *Sabini* from the *Iguvini*, who remained in the upper Tiber valley. From the Sabines sprang the Samnites at a later date. It seems certain that these people brought iron into Italy and buried the dead, and probable that they formed the patrician class at Rome.

Especial interest attaches to this distinction of two strata in the early Indo-European population of Italy because the oldest and most striking linguistic change which marks off the -CO- folk seems to be that of Q to P (Volscian *pis* = Latin *quis*[1]). Now this same change, as is well known, separates the later from the earlier Keltic dialects of the British Isles, Goidelic, *i.e.* Gaelic and Irish, having kept the original guttural, for which Brythonic, *i.e.* Welsh, Breton, &c., substituted P (Scotch *Mac* = Welsh [*M*]*Ap*). The Keltic languages are the next congeners to Italic, and the dates to which archæologists ascribe the two Keltic invasions of Britain are not remote from that at which the Samnites overran Southern Italy. Were the movements the result of some one cause in Central Europe?

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7. *The Origin of Jewellery.*[2] *By* Professor W. Ridgeway.

Personal ornaments in civilised countries consist of precious metals, stones, or imitations of stones, pearls (which are the product of shells), or shells themselves, amber, jet, and occasionally various other objects, such as tigers' claws, &c. It has hitherto been held that men and women were led by purely æsthetic considerations to adorn themselves with such objects; but a little research into the history of such ornaments leads to a very different conclusion. The fact is that mankind was led to wear such objects by magic rather than by æsthetic considerations. The jewellery of primitive peoples consists of small stones with natural perforations, *e.g.*, silicified sponges or joints of coniferæ, or of substances easily perforated, such as amber, the seeds of plants, shells, the teeth and claws of animals, bones, or pieces of bone, and pieces of wood of peculiar kinds. Later on they learn to bore hard stones, such as rock crystal, hematite, agate, garnet, &c., and obtain the metals.

[1] The Samnite change of *q* to *p* appears to me to have happened at a recent date, and under certain conditions not to have happened at all.

[2] To be published in full in *Journ. Anthr. Inst.* xxxiv.

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All peoples value for magical purposes small stones of peculiar form or colour long before they can wear them as ornaments; *e.g.* Australians and tribes of New Guinea use crystals for rain-making, although they cannot bore them, and it is a powerful amulet in Uganda fastened into leather. Sorcerers in Africa carry a small bag of pebbles as an important part of their equipment. So was it in Greece. The crystal was used to light sacrificial fire, and was so employed in the Church down to the fifteenth century. The Egyptians under the twelfth dynasty used it largely, piercing it along its axis after rubbing off the pyramidal points of the crystal, sometimes leaving the natural six sides, or else grinding it into a complete cylinder. From this bead came the artificial cylindrical beads made later by the Egyptian, from which modern cylindrical glass beads are descended.

The beryl, a natural hexagonal prism, lent itself still more readily to the same form, *e.g.* the cylindrical beryl beads found in Rhodian tombs. The Babylonian cylinders found without any engraving on them on the wrists of the dead in early Babylonian graves had a similar origin. It has been universally held that Babylonian cylinders, Egyptian scarabs, and Mycenean gems were primarily signets; but as the cylinders are found unengraved, and as many as 500 scarabs are found on one mummy, and as Mycenean stones are often found without any engraving, it is clear that the primary use was not for signets but for amulets. The Orphic Lithica gives a clear account of the special virtue of each stone, and it is plain that they acted chiefly by sympathetic magic; *e.g.* green jasper and tree agates make the vegetation grow, &c. The Greeks and Asiatics used stones primarily as amulets, *e.g.* Mithridates had a whole cabinet of gems as antidotes to poison. To enhance the natural power of the stone a device was cut on it, *e.g.* the Abraxas cut on a green jasper, the special amulet of the Gnostics. The use of the stone for sealing was simply secondary, and may have arisen first for sacred purposes.[1] Shells are worn as amulets by modern savages, *e.g.* cowries in Africa, where these or some other kind of shells were worn in Strabo's time to keep off the evil eye.

Red coral was a potent amulet worn by travellers by sea, as at the present day in Mediterranean lands, and if pounded up it kept red rust from corn. Pearls are a potent medicine in modern China. Seeds of plants are medicine everywhere; for example, the ratti (*Abrus precatoria*) is used in India for rosaries, and also in Africa; the seed of wild banana is especially valued in Uganda, &c. The claws of lions are worn as amulets all through Africa, and are 'great medicine,' and imitations of them are made. So with teeth of jackals, which are imitated in wood if the real ones are not to be had, and boars' tusks in New Guinea. When gold becomes first known it is regarded exactly like the stones mentioned. Thus the Debæ, an Arab tribe, who did not work gold, but had abundance in their land, used only the nuggets, stringing them for necklaces alternately with perforated stones.[2] Magnetic iron and hematite were especially prized, the power of attraction in magnetic iron, as in the case of amber, causing a belief that there was a living spirit within. Hence iron in general was regarded with peculiar veneration, and not because it was a newer metal, as is commonly stated.

It is thus clear that the use of all the objects still employed in modern jewellery has primarily arisen from the magical powers attributed to them, by which they were thought to protect the wearer.

TUESDAY, SEPTEMBER 15.

The following Report and Papers were read:—

1. *Report of the Committee on Archæological and Ethnological Researches in Crete.*—See Reports, p. 402.

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[1] *Cf.* Herod. ii. 38.

[2] Strabo, p. 778.

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2. *Excavations at Knossos in Crete.*[1] *By* A. J. Evans, *M.A., D.Litt., F.R.S.*

See Reports, p. 402.

3. *Exploration in the East of Crete.*[1] *By* R. C. Bosanquet, *M.A.*

The fourth Cretan campaign of the British School at Athens lasted from March to June 1903. The headquarters of the expedition were again at Palæokastro on the east coast. The work done may be summarised as follows:—

1. The excavation of the settlement discovered last year at Roussolakkos was continued with the help of Mr. M. N. Tod and Mr. R. M. Dawkins. It proves to be a considerable town, regularly laid out in streets and blocks. The streets are narrow, from 5 to 12 feet wide, well paved, with a raised footpath at one side and a deep gutter at the other. One main street has been cleared for over 150 yards. Each block has a frontage of from 120 to 180 feet, and contains three or more houses. The general plan of the town and parts of the houses date from the latter part of the Kamáres period, but there was extensive rebuilding during the Mycenæan period. House-fronts in ashlar masonry, bath-rooms, drainage arrangements, and a great variety of domestic utensils, indicate widespread prosperity and comfort. The inhabitants had wheat and peas; they made oil and probably wine. They imported obsidian from Melos, green porphyry from the Peloponnese, and liparite from the Lipari Islands. Their wealth was probably derived from trade with Egypt.

Marine designs, such as rocks, corals and seaweed, shells and cuttlefish, predominate on the Mycenæan vases found this year. The yield of pottery was exceptionally large; Mr. C. T. Currelly has made coloured drawings of the finer specimens.

2. The ossuaries outside the town were further excavated by Mr. W. L. H. Duckworth, whose report on the skulls and bones from them was read on Thursday.

3. The surrounding region was explored. A pre-Mycenæan sanctuary was discovered on the hill of Petsofá, above the town, and remains of an equally early purple-factory on the island of Koufonisi; the former will be described by Mr. J. L. Myres, the latter by Mr. Bosanquet; Mr. C. T. Currelly took part in both investigations. Caves and rock-shelters were examined in the limestone plateau of the interior, and a Mycenæan farmstead was excavated at Kouraméno.

4. The physical characteristics of the present population were studied by Mr. Duckworth, and their dialect by Mr. Dawkins.

4. *An Early Purple-fishery.*[1] *By* R. C. Bosanquet, *M.A.*

Leuke, the 'White Isle' (modern Kouphonisi), off the south-east coast of Crete, was an important fishing-station in antiquity. The tithes levied on the catch of fish and of purple-shell, mentioned in an inscription of about 350 B.C., must have been very profitable, for the possession of the island was the subject of a long and bitter dispute among three neighbouring cities.

Last May the island was explored by Mr. C. T. Currelly and the writer. Among sand-hills on the north shore they found a bank of shells, some whole but mostly crushed, of the variety *Murex trunculus*, which is known to have been used in the manufacture of the purple dye. Scattered through the heap were fragments of pottery and of a stratile bowl which marked it as not only præ-Hellenic but præ-Phœnician. Further digging within a few yards of the heap brought to light characteristic Cretan vases of the Kamáres type and the foundations of a house.

The evidence shows that the extraction of the purple-juice was practised in

[1] To be published more fully in the *Annual of the British School of Archæology at Athens*, ix.

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Crete at least as early as 1600 B.C. Hitherto the Phœnicians have been credited with the discovery of 'Tyrian purple.' It appears, however, that in this matter, as in the art of writing and perhaps in other inventions attributed to the Phœnicians by Greek authors, the Minoans of Crete were the real pioneers.

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5. *On a pre-Mycenæan Sanctuary with Votive Terracottas at Palæokastro, in Eastern Crete.*[1] *By* JOHN L. MYRES, *M.A.*

This sanctuary stands on the summit of the hill called Petsofà, which bounds the bay of Palæokastro southward, and was excavated in April 1903. A massive retaining wall of large rudely shaped blocks incloses, on south and west, a roughly rectangular space, the northern face of which is bounded by a precipitous descent, and the eastern face by low ridges of natural rock.

Within the inclosure were found (from the bottom upwards) (1) a layer of undisturbed soil resting on the southward-shelving rock surface; (2) a layer of blackened ashy earth, apparently the remains of a large hearth or bonfire, full of whole and broken terracotta figurines, with painting of the Minoan (pre-Mycenæan) technique; (3) a layer of disturbed soil obliterating the ashy layer and containing fragments of its figurines; (4) over all a rubble building of early Mycenæan date, like those of the settlement-site at Palæokastro,[2] one room of which still retained its plastered and whitewashed floor, with a plastered bench round three sides, and the remains of a door. A column-base from an earlier building was found built into its foundations.

The terracottas include figures of men and women in characteristic pre-Mycenæan costume, analogous to that shown on the frescoes at Knossos, and completed in the case of the women by gigantic and very stylish hats; a quite new feature. Other terracottas represented miniature oxen, rams, goats, pigs, dogs, weasels, hedgehogs, birds, chairs, miniature vases, and other objects of daily use, together with the horns and legs of a larger series of oxen, the bodies of which appear to have been completely cleared away from the ash-heap from time to time. A very large number of quite plain clay balls, of about the size of a marble, seem to be votive like the other offerings, but are not so easily explained: they may, however, represent occasions of prayer or thanksgiving which defied the ingenuity of the modeller.

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6. *The Temples of Abydos.*[3]
By Professor W. M. FLINDERS PETRIE, *D.C.L., LL.D., F.R.S.*

After Mariette had worked on the ground of the Osiris temple at Abydos he declared that nothing remained of the old temple, that even the foundations had been destroyed to the roots, and that any further research was impossible. From that very ground, the work of the past winter has produced foundations of ten successive periods of the temple, one below the other, occupying nearly 20 feet depth of soil. The examination and recording of these buildings has required over four thousand measurements and one thousand levellings. The highest temple was of Amasis (XXVI. dynasty), then Rameses III. (XX. dynasty), then Amenhotep III., Thothmes III., and Amenhotep I. (XVIII. dynasty); then Sebekhotep III. and Usertesen I. (XIII.–XII. dynasty), then Sankhkara (XI. dynasty), then Mentuhotep III. (XI. dynasty), then Pepy (VI. dynasty), then the temple of the fourth dynasty, below that of the second, and at the base of all the oldest temple of the first dynasty. Thus the site was continually re-used during four thousand years, each of these periods of building followed entirely different lines, and the successive plans had scarcely any relation one to another.

[1] To be published in full in *Ann. Brit. School. Athens*, ix.
[2] E.g., *Ann. Brit. School. Athens*, vol. viii. p. 311, fig. 24.
[3] Published in full in the author's *Abydos*, I., II. (Egypt Exploration Fund).

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The principal results are in the first dynasty. The school of fine ivory carving at that time shows work equal to any that succeeded it in later history. The appreciation of form, the delicacy of the muscular curves, and the power of expression is as good as in the best classical or renaissance carvings. The art of glazing was applied to large wall-tiles, used for covering brick walls, and to vases, as shown by part of a large vase with the name of Menes. The use of two-colour glazes, a purple inlay in green, appears in the name of Menes. Hence glazing was as advanced at the beginning of the first dynasty, about 4700 B.C., as it was for three thousand years later, until the polychrome glazes of the eighteenth dynasty.

The European relations of Egypt are further illustrated by finding the same black pottery in the first dynasty that is known in Crete as late neolithic. The camel is shown in the first dynasty by a well-modelled head; hitherto it was not proved to have been in Egypt till about four thousand years later.

In the well-known age of the fourth dynasty we have for the first time the portrait of the best known of all the kings, Cheops or Khufu, whose appearance, however, was as yet quite unknown. A minutely carved ivory figure, the face of which is only $\frac{1}{8}$ inch high, shows his character in an astonishing manner. The energy, decision, and driving power is perhaps stronger than in any other portrait that we know. The tradition of his closing the temples and forbidding sacrifices is fully confirmed by finding that no large temple existed in the fourth dynasty, such as those of the earlier or later times; only a bed of vegetable ashes is found in a cell, and throughout it hundreds of clay *flotilia* as substitutes for sacrifices, not a single bone of an animal occurring in the whole mass.

The worship in the temple of Abydos was originally that of the jackal god Up-uatu, 'the opener of ways,' who showed the paths in the desert for the souls to go to the west. Osiris does not appear in any temple inscription for two thousand years, and is not prominent till yet later. Some large decrees of the fifth and sixth dynasties were found; and the oldest piece of certainly dated iron, apparently a wedge, of the sixth dynasty, about 3400 B.C. This site has fully shown how important it is to dissect minutely a temple site in which only earth remains, and where at first the absence of stone walls might lead to the idea that nothing was left there; the art of the beginning of the Egyptian monarchy lay hidden in that ground.

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7. *The Beginning of the Egyptian Kingdom.*

By Professor W. M. Flinders Petrie, *D.C.L., LL.D., F.R.S.*

For generations past the origins of Egyptian civilisation had been a mystery; the earliest period there known, the pyramid times, showed a very high civilisation, and its rise was entirely unknown. In the past ten years most of the stages which led from a savage state up to the highest development have been brought to light. The discovery of the prehistoric age and its division into regular sequences of remains has filled up a period of over two thousand years, which—beginning with men in goatskins with the simplest pottery—ran through a wealthy and elaborate age of civilisation, and was in decadence when it was overthrown by the dynastic Egyptians. Of the five different types of man before the dynasties, portraits of which were published two years ago, the fifth type, with the forward beard, is from the monuments shown to be Libyan, and thus easily connected with the same type in early Greece.

The rise of the dynastic power has been brought to light in the remains of the royal tombs of the first and second dynasties, and some probably before the first dynasty, excavated at Abydos in 1900 and 1901. The connection of the close of the prehistoric scale of sequence with the early kings has been closely settled by the pottery, and its history shown in the stratified ruins of the earliest town of Abydos; so that we pass without a break from the sequence dates of the prehistoric age to the historic reigns of the kings. Four kings' names are found which, from the nature of their remains and their tombs, appear to belong to the dynasty of ten kings which preceded Menes, the first king of all Egypt.

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Of the first dynasty all the eight kings have been identified; their tombs, vases, sealings, and officials are all now familiar to us, and we can trace the gradual changes between one reign and another as clearly as we can during the last century or two. The growth of the use of writing can be well seen on the seals, the impressions of over two hundred of which have been collected. At first only a single sign for a proper name of a king; then a more complex name; then the vizier named with the king; next the titles of various officials; and in the end of the second dynasty full names and titles in a style as complete as in any later age. The art of the dynastic people was entirely different from any of the prehistoric age, though it united with it and took over some features of it. Broadly, the pre-dynastic people were mechanical, and the dynastic race was artistic; and even in the earliest works of the kings there is an ability of the best style, though still archaic. By the end of the reign of Menes and under his successor the artistic types had become fairly fixed, and they remained the patterns to which the Egyptian recurred at each successive renewal of art during four thousand years. The most completed stage was in the middle of the first dynasty, and at its close there is certain degradation. The state of art between the first and the fourth dynasties is not yet clear; it seems to have become conventional and probably devitalised until it made a fresh start with the great expansion of activity under the pyramid builders. The royal tombs of the early kings were enlarged forms of the prehistoric graves. A pit in the ground had during the prehistoric age been improved on by making it a large chamber lined with mats, roofed with timber and brushwood, and furnished with an abundance of vases and objects. The earliest royal tombs are much the same, only lined and floored with timber, the offerings being dropped in between the timber lining and the side of the pit. Then regular cells were built for the offerings; next, a row of small chambers apart from the tomb; and lastly, an elaborate series of store chambers of various sizes. The tomb originally had no entrance; then a sloping hole leads to it, next a stairway, and lastly a long sloping passage as in the pyramids. The outer form was at first a slightly raised heap over the roof of the tomb. This was next walled round to retain the earth; after that the walling was raised and formed a block of brickwork with sloping sides on the early brick *mastaba*. This later became expanded by additions around it and extension upward, so as to be a mass of concentric coats; and when translated into stone at the end of the third dynasty it suggested pyramidal outline, and so originated the pyramid type.

For the first time we can now see what was going on in each generation over a period of nine or ten thousand years; a few dark times still need the filling in of details, but the general course of man's development and abilities can now be understood with a completeness which gives a solid basis for some general views. Archæology and history, the scientific knowledge of the past of man, gives us the surest comparisons for estimating his future.

WEDNESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *On the Occurrence of Stone Implements in the Thames Valley between Reading and Maidenhead.*[1] *By* Ll. Treacher.

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2. *The Rapid Evolution of the Jamaica Black.*
By Miss Pullen-Burry.

This paper deals with the fusion of racial elements in the black and coloured peoples of Jamaica, and their present civilisation in so far as the safety of life and the security of property are concerned. A unique feature in this island appears

[1] See Proceedings of Section C., p. 670. Published in full in *Man*, 1904, 10.

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to be the moulding of an African people (all trace of the aboriginal Arawak and Spaniard being completely lost in the all-prevailing negroid type) by English and Scotch life and thought, no other influence having come in contact with the race. Here, too, it appears possible to have one civilisation alike for black, coloured, and white, which is not the case in America. The reasons given for this rapid evolutionary development since the emancipation of the slaves in 1834-38 are: (1) the security of a solid government; (2) widespread education afforded by 757 schools; (3) an active religious propaganda rapidly suppressing Obeahism; (4) easy conditions of life: the scant needs of the negro are easily met; (5) state-aided settlement of lands on deferred payments, which is establishing a growing class of peasant-proprietors.

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3. *Mongoloid Europeans.* *By* DAVID MACRITCHIE.

A careful consideration of the relics of the Cave-men of Europe has led Professor Boyd Dawkins to the conclusion that the Eskimos of the present day are almost certainly their representatives, and that the connection between these two peoples must be one of blood. He does not ignore the possibility of descendants of the Cave-men having survived into historic times in Europe; but he is of opinion that the Eskimo type has long been extinct in Europe.

Here he is at variance with the deductions of Dr. Beddoe, made after an analysis of the race-elements in modern Britain, to the effect that 'some reason can be shown for suspecting the existence of traces of some Mongoloid race in the modern population of Wales and the west of England.'

While stating his belief that the Cave-men of Eurasia were driven eastward into North America, where their descendants now exist as Eskimos, Professor Boyd Dawkins points out that North-eastern Siberia yet retains an Eskimo population—the Chukches. Martinière, however, reports in the Yalmal peninsula, in 1653, a people closely resembling modern Eskimos in physical appearance, in dress and manners, and, above all, in their use of the peculiar skin-covered skiff generally known as a *kayak*. These skin-canoes are not reported in Arctic Europe during the last few centuries; but they are said to have been used in the Orkney Islands by a race of occasional visitors, locally called 'Finnmen,' between the years 1682 and 1701. The minute accounts given of the canoes of these Finnmen leave no doubt that they were *kayaks*. One of them was preserved in the Church of Burra, Orkney, for a time; and another in the Physicians' Hall, Edinburgh. Popular tradition in Orkney and Shetland contains many references to these 'Finnmen' or 'Finns,' who are said to have frequently intermarried with the islanders. These islanders are mainly Norsemen, and in the Norse language 'Finn' signified 'Lapp.' The historical statements and the traditions relating to 'Finns' denote really, therefore, an intercourse and a partial fusion between the islanders and a Lapp people accustomed, like modern Eskimos, to the use of the *kayak* and all that that implies. Such a fusion would readily explain the Mongoloid features seen in certain Shetlanders by Dr. Beddoe.

It is noteworthy that the territory occupied by the Lapps in the ninth century included the greater part of Scandinavia, and straggling remnants of that population may have survived for many centuries in Southern Scandinavia. Martinière even speaks of a Lapp village near Christiania in 1653.

There seems to be no trace of the use of the skin canoe among modern Lapps, but von Düben states that the mountain Lapps assert that their remote forefathers, who came from the south-east of Europe, crossed the sound which separates Denmark from Sweden in small skin-boats.

If this tradition be accepted as accurate, it is reasonable to suppose that remnants of the Lapps who were able to prolong their existence among the fiords, long after the days of 'Norse' invasion from the Continent, would at the same time continue to use the skin canoes of their race, and this long after the inland Lapps had ceased to know anything of such vessels, except from tradition. This hypothesis would readily account for the existence of coast-dwelling Lapps who

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crossed from Scandinavia to Orkney and Shetland in their *kayaks* as recently as the seventeenth century.

This conclusion supports Dr. Beddoe's belief that there is a Mongoloid element among western Europeans. If the Mongoloid people assumed by Professor Boyd Dawkins to have existed in Western Europe in primitive times really died out, it seems necessary to suppose that there was a fresh Mongoloid immigration at a much later date, *e.g.* the Hun conquests of the fifth century. But there appears to be ample evidence that Europe contained a truly Mongoloid population long before the era of Hun domination, and even that the European Cave-men have never ceased to be represented by people who have inherited their blood.

4. *Some Points about Crosses, chiefly Celtic.* *By* Miss A. A. Bulley.

The paper deals with certain details only, and has nothing to do with the general question of *origin*. In considering the *form* of the crosses, however, regard is had to the *feeling* underlying the treatment, so far as this can be gathered from a general survey of the examples. Argument from *form* alone is necessarily imperfect, and may be fallacious, though it may suggest lines of investigation. In default of historic data, however, it is the only method possible.

1. *Celtic crosses.*—From a survey of examples from Cornwall, Wales, the Isle of Man, Scotland, and Ireland the author infers that in Celtic crosses—(i.) the *circle* (whatever its meaning and however related eventually to the ends of the arms) is not a mere adjunct (such as a glory, or a support for the arms), but is of at least equal importance with the *cross*. The persistence of such a form without meaning points to an earlier period when the form represented an idea of primary importance. The circle is therefore inferred to be here a root-idea. (ii.) The long-shafted or Latin type appears to be an independent development from the cross-with-circle-and-equal-arms. The author does not attempt to decide whether or no this development was influenced by the introduction of the pure 'Latin cross' from outside.

2. *Non-Celtic crosses*, on the other hand, exhibit lesser importance and weaker treatment of the circle, *e.g.*:—

(*a*) Coptic crosses, though often inclosed in a wreath, are often without. Later, the *ankh* symbol is confused with the cross.

(*b*) Roman (catacomb) crosses in their earliest form are equal-armed, but the circle is optional. The long-shafted or 'Latin' form is later, and possibly developed (in Italy) from processional use. The treatment also of these early crosses is not *realistic* but *symbolic*; whereas the course of development is never from symbolic to realistic, but the reverse.

(*c*) Syrian crosses resemble catacomb-crosses, but are even more decorative in treatment. The extant examples, however, are chiefly architectural ornaments, which may account for this. The circle is optional.

5. *Some Suggestions as to the Origin of the Brooch, and the probable Use of certain Rings at present called 'Armlets.'* *By* Edward Lovett.

The author suggests, as the prototype of the ring-and-pin contrivance for fastening a cloak, the use, by a hunting people, of the mammalian *Os innominatum* and *Os calcis*, the corners of the cloak being drawn through the oval perforation of the former and then pierced by the sharp point of the latter. In this position the prominences on the *Os calcis* would drop into the hollow of the *Os innominatum* and prevent the *Os calcis* from falling out of place.

The author notes, further, that very many rings of early date and various materials—bone, jet, shell, bronze, and iron—which are usually described as 'armlets' are of too small diameter to allow the entrance even of an infant's hand. As such rings are frequently found associated with pins of similar materials,

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commonly regarded as 'hair-pins,' and as ring and pin are sometimes found *in situ* on the breast of a skeleton, it is inferred that they represent a simple ring-and-pin fastening of the kind described above. An apron-fastener of this type, composed of an iron ring and a horse-shoe nail, is still worn in some of the blacksmiths' shops in Scotland.

The next step of development is taken when the pin is perforated at the thick end and attached to the ring by a fibre to prevent it from being lost. This stage is actually represented by a ring-and-pin fastening which is in common use in China: the ring is of agate, and the pin, which is of silver, is attached to it by a silken thread. Probably many of the perforated pins in our museums were similarly attached to rings.

An apron-fastener of the simple ring-and-pin type, composed of an iron ring and a horse-shoe nail, is still worn in some of the blacksmiths' shops in Scotland; a similar simple brooch is still worn by the shepherds of Perthshire and by the tinkers in this and other parts of Scotland; and another similar form was in very common use in Donegal as late as 1860.

A further step is taken when the pin itself is hinged upon the ring, for security, by bending its flattened head round the ring. This form is abundant in Celtic times. The Tara brooch is a striking example, though the author suggests that it may be a symbolic reversion to an earlier type.

The inconvenience which accompanies the use of the ring-and-pin brooch, that the fabric to be fastened must be drawn far through the ring before the pin can pierce it, was remedied, it is suggested, by leaving a gap in the ring; and from this results the 'penannular' brooch with its many varieties.

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6. *On the Ethnology of the Siciutl Indians of British Columbia.*[1] *By* C. HILL TOUT.

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7. *On the Canadian Indians as they are.* *By* DAVID BOYLE.[1]

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8. *On the Legends of the Dieri and Kindred Tribes of Australia.*[1] *By* A. W. HOWITT *and* OTTO SIEBERT.

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9. *A West Indian Aboriginal Wooden Image.* *By* J. E. DUERDEN, *Ph.D.*

This figure represents one of the most characteristic types of West Indian wooden images, several of which are now known from different islands. They have been found mostly in caves, and historic references to such objects of worship or *zemes* in Columbian times are available. The present example represents a single crouching human figure, terminated above by a large circular canopy and resting upon an irregular wooden base. The face is very large; the ears are indicated by an upper smaller and a lower larger lobe, both perforated. The eye and mouth apertures are formed in the usual rounded manner, with thickened margins. The arms and legs are constricted, as by the wearing of circular bands; small mammæ, ribs, and a large erect virile-organ are indicated.

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10. *On a Model of the Arbor Low Stone Circle.* *By* H. BALFOUR, *M.A.*

[1] To be published in full in *Journ. Anthr. Inst.* xxxiv.

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SECTION K.—BOTANY.

PRESIDENT OF THE SECTION.—A. C. SEWARD, M.A., F.R.S.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

IN 1883, the date of the last meeting held by the British Association at Southport, the late Professor Williamson, of Manchester, delivered a Presidential Address before the Geological Section, in which he reviewed recent progress in palæobotanical research, with special reference to the vegetation of the Coal period. It would have been an interesting task to traverse the same ground to-day, in order to show what a vast superstructure has been built on the foundations which Williamson laid. In alluding to the controversies in which he bore so vigorous a part, Williamson spoke of the conflict as virtually over, though still reflected 'in the ground-swell of a stormy past.' Now that twenty years have elapsed we are able to recognise with no little satisfaction that his views are firmly established, and that the debt which we owe to his able interpretation of the relics of Palæozoic plant-life is universally acknowledged. Williamson's labours demonstrated the possibilities of microscopical methods in the investigation of Carboniferous plants; but at the time of publication his results did not receive that attention which their importance merited, and it is only in recent years that botanists have been induced to admit the necessity of extending their observations to the buried treasures of bygone ages. We have been slow to realise the truth of the following statement, which I quote from an able article on Darwinism in the 'Edinburgh Review' for October of last year: 'The recognition of the fact that in every detail the present is built on the past has invested the latter with a new title to respect, and given a fresh impulse to the study of its history.' The anatomical investigation of extinct types of vegetation has done more than any other branch of botanical science in guiding us along the paths of plant-evolution during the earlier periods of the earth's history.

I cannot conclude this brief reference to Williamson's work without an expression of gratitude for the help and encouragement with which he initiated me into the methods of palæobotanical research.

FLORAS OF THE PAST: THEIR COMPOSITION AND DISTRIBUTION.

Introduction.

It is by no means easy to make choice of a subject for a presidential address. There is the possibility—theoretical rather than actual—of a retrospective survey of modern developments in the botanical world, and the opportunity is a favourable one for passing in review recent progress in that department of the science

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which appeals more especially to oneself. In place of adopting either of these alternatives, I decided to deal in some detail with a subject which, it must be frankly admitted, is too extensive to be adequately presented in a single address. My aim is to put before you one aspect of palæobotany which has not received its due share of attention: I mean the geographical distribution of the floras of the past. In grappling with this subject one lays oneself open to the charge of attempting the impossible—a not unusual characteristic of British Association addresses. I recognise the futility of expecting conclusions of fundamental importance from such an incomplete examination of the available evidence as I have been able to undertake; but a hasty sketch may serve to indicate the impressions likely to be conveyed by a more elaborate picture.

One difficulty that meets us at the outset in approaching the study of plant distribution is that of synonomy. 'The naturalist,' as Sir Joseph Hooker wrote in his 'Introductory Essay to the Flora of New Zealand,' 'has to seek truth amid errors of observation and judgment and the resulting chaos of synonymy which has been accumulated by thoughtless aspirants to the questionable honour of being the first to name a species.' Endless confusion is caused by the use of different generic and specific names for plants that are in all probability identical, or at least very closely allied. Worthless fossils are frequently designated by a generic and specific title: an author lightly selects a new name for a miserable fragment of a fossil fern-frond without pausing to consider whether his record is worthy of acceptance at the hands of the botanical palæographer.

An enthusiastic specialist is apt to exaggerate the value of his material, and to forget that lists of plants should be based on evidence that can be used with confidence in investigations involving a comparative treatment of the floras of the world. As Darwin said in the 'Origin of Species': 'It is notorious on what excessively slight differences many palæontologists have founded their species; and they do this the more readily if the specimens come from different sub-stages of the same formation.' It would occupy too much time to refer to the various dangers that beset the path of the trustful student, who makes use of published lists of local floras in generalising on questions of geographical distribution during the different eras of the past. Such practices as the naming of undeterminable fragments of leaves or twigs, the frequent use of recent generic names for fossil specimens that afford no trustworthy clue as to affinity, belong to the class of offences that might be easily guarded against; there are, however, other obstacles that we cannot expect to remove, but which we can take pains to avoid. An author in naming a fossil plant may select one of several generic names, any of which might be used with equal propriety; individual preferences assert themselves above considerations as to the importance of a uniform nomenclature. The personal element often plays too prominent a part. To quote a sentence from a non-scientific writer: 'The child looks straight upon Nature as she is, while a man sees her reflected in a mirror, and his own figure can hardly help coming into the foreground.'

In endeavouring to take a comprehensive survey of the records of plant-life, we should aim at a wider view of the limits of species and look for evidence of close relationship rather than for slight differences, which might justify the adoption of a distinctive name. Our object, in short, is not only to reduce to a common language the diverse designations founded on personal idiosyncrasies, but to group closely allied forms under one central type. We must boldly class together plants that we believe to be nearly allied, and resist the undue influence of considerations based on supposed specific distinctions.

The imperfection of the Geological record was spoken of by one of England's greatest geologists, in a criticism of the 'Origin of Species,' as 'the inflated cushion on which you try to bolster up the defects of your hypothesis.' On the other hand, Darwin wrote in 1861: 'I find, to my astonishment and joy, that such good men as Ramsay, Jukes, Geikie, and one older worker, Lyell, do not think that I have in the least exaggerated the imperfection of the record.' No one in the least familiar with the conditions under which relics of vegetation are likely to have been preserved can for a moment doubt the truth of Darwin's words: 'The crust

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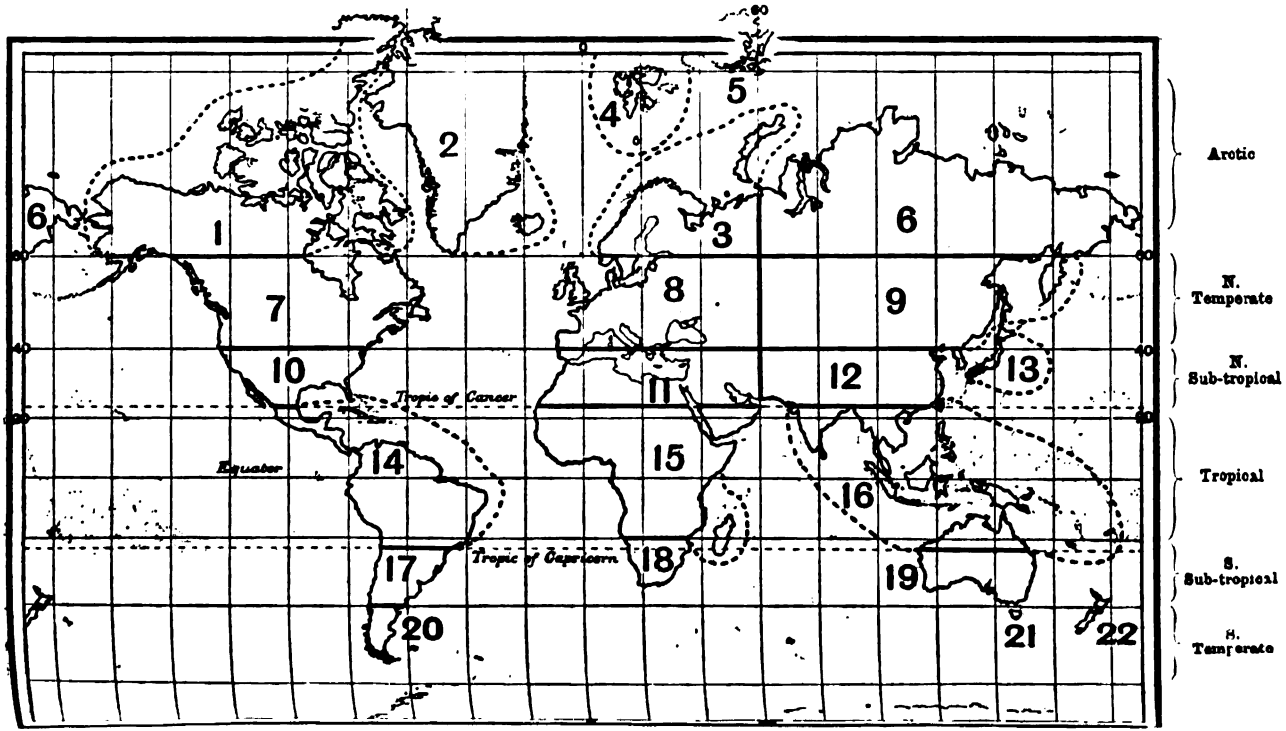
MAP I.—The Earth's Surface divided into Areas (1–22) for convenience in recording the Geographical Distribution of Fossil Plants.



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the earth, with its embedded remains, must not be looked at as a well-filled useum, but as a poor collection made at hazard and at rare intervals.'

As a preliminary consideration, we must decide upon the most convenient eans of expressing the facts of geographical distribution in a concise form. The cognised botanical regions of the world do not serve our purpose; we are not ncerned with the present position of mountain-chains or wide-stretching plains iat constitute natural boundaries between one existing flora and another, but mply with the relative geographical position of localities from which records of ncient floras have been obtained. In the accompanying map I have divided the rface of the earth into six belts, from west to east. The most northerly or *Arctic Belt* includes the existing land-areas as far south as latitude 60°, comrising—1, Northern Canada; 2, Greenland and Iceland; 3, Northern Europe; , Bear Island and Spitzbergen; 5, Franz Josef's Land; 6, Northern Asia. The *North Temperate Belt*, extending from latitude 60° to 40°, includes—7, South Canada and the northern United States; 8, Central and Southern Europe; 9, Central Asia. The *North Sub-tropical Belt* comprises the land between latitude 40° and the Tropic of Cancer, including—10, the Southern States of North America; 1, Northern Africa, part of Arabia and Persia; 12, Thibet and part of China; 3, Japan. The *Tropical Belt*, embracing the land-areas between the Tropics of Cancer and Capricorn, includes—14, Central America and the northern part of South America; 15, Central Africa and Madagascar; 16, India, the Malay Archipelago, and Northern Australia. The *South Sub-tropical Belt*, extending from the Tropic of Capricorn to latitude 40° south, includes—17, Central South America; 18, South Africa; 19, Central and Southern Australia. The *South Temperate Belt* includes—20, the extreme south of South America; 21, Tasmania; 22, New Zealand.

Pre-Devonian Floras.

The scanty records from pre-Devonian rocks afford but little information as to the nature of the vegetation that existed during the period in which were deposited the Cambrian, Ordovician, and Silurian strata that now form the greater portion of the Welsh and Cumberland hills. We must wait for further discoveries before attempting to give more than the barest outline of the plant-life of these remote epochs. Our knowledge of the plant-world which existed during the Silurian period is far too meagre to justify any statement as to geographical distribution. Of the few records of supposed Silurian plants, several have been shown to be unsatisfactory, and the nature of others is too uncertain to admit of accurate identification. The Lepidodendron-like fossil from the Clinton limestone of Silurian age in Ohio, described by Claypole in 1878 as *Glyptodendron*, has been referred by a later writer to a Cephalopod. Stur's Bohemian plants, described in 1881, are too imperfect to afford any information of botanical value; while the ferns and lepidodendroid plants recently recorded by Potonié from the Hartz Mountains are more likely to be of Devonian than Silurian age.

The genus *Nematophycus*, originally described by Dawson as *Prototaxites*, and afterwards referred by Carruthers to the Algæ, constitutes the most satisfactory example of a Silurian plant. This genus, which has fortunately been preserved in such a manner as to admit of minute microscopical examination, represents a widely spread algal type in Silurian and Devonian seas. It has been found in Silurian strata in Wales, Shropshire, and New Brunswick; also in Devonian rocks of Eastern Canada, New York, Ohio, and North-West Germany. The tubular elements composing the stems of some species of *Nematophycus*—which reached a diameter of 2 or 3 feet—exhibit a regular variation in width, giving the appearance of concentric rings of growth, as in the stems of the tree-like *Lessonia*, an existing genus of Antarctic seaweeds. This structural feature presents an impressive image in stone of a plant's rhythmical response to some periodically recurring conditions of growth in the waters of Palæozoic seas.

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Devonian and Lower Carboniferous Floras.

The earliest plants that have been found in sufficient number, and in a state of preservation which renders their identification possible, are those from Devonian rocks. From Bear Island, a small remnant of land situated within the Arctic circle, the late Professor Heer described several Devonian plants; and more recently Professor Nathorst, of Stockholm, has given a full account of this interesting and comparatively rich flora. The relics of plant-life preserved in this Arctic island carry us back through countless ages to a time when a luxuriant vegetation flourished in a region now occupied by ice-bound land and polar seas. As Edward Fitzgerald said, in speaking of his enjoyment of some geological book: 'This vision of time is in itself more wonderful than all the conceptions of Dante and Milton. Devonian plants have been described by Feistmantel, Etheridge, and others from Australia; and the well-known Kiltorkan grits of Ireland have supplied a few well-preserved impressions of the oldest land-plants disinterred from British rocks.

As my aim is to sketch in broad outline the general facies of the vegetation which flourished at different stages in the earth's history, rather than to undertake a critical examination of the evidence as to the precise geological age of the plant-bearing beds, I propose to treat of Devonian and Lower Carboniferous floras as constituting one phase in the evolution of the plant-world. In speaking of the plants of the Devonian and Lower Carboniferous or Culm phase, it is not assumed that the specimens entombed in the snow-covered cliffs of Bear Island were actually contemporaneous with those found in rocks of the same geological period in the Southern hemisphere. The Bear Island rocks are, in the language which Huxley taught us to use, homotaxial with certain Devonian plant-bearing strata in other parts of the world; they occupy the same relative position in the geological series.

Homotaxy by no means implies contemporaneity; indeed, the late Edward Forbes maintained that similarity of organic contents of distant formations should be accepted as *prima facie* evidence of a difference in age.

What do we know as to the composition of the floras that flourished in the later stages of the Devonian and in the latter part of the Carboniferous era? The following list, which is by no means exhaustive, represents some of the more important generic types which may be very briefly described:—

1. EQUISETALES.
   - *Archæocalamites.*

2. SPHENOPHYLLALES.
   - *Sphenophyllum.*
   - *Cheirostrobus.*
   - [*Pseudobornia* ?]

3. LYCOPODIALES.
   - *Lepidodendron.*
   - *Bothrodendron.*

4. FILICALES.
   - *Archæopteris.*
   - *Adiantites.*
   - *Rhodea.*
   - *Cardiopteris.*
   - *Todeopsis.*
   - *Cephalotheca.*
   - *Rhacopteris.*

5. CYCADOFILICES.
   - *Calamopitys.*
   - *Heterangium.*
   - *Lyginodendron.*

6. GYMNOSPERMÆ.

   (CORDAITALES.)
   - *Cordaites.*
   - *Pitys.*

In *Archæocalamites* we have the oldest example of an undoubted Equisetaceous genus. The structure of its comparatively thick and woody stem is practically identical with that of our common British type of *Calamites*, one of the most abundant of the Coal period genera, while the strobilus differed in no essential feature from that of a modern Horsetail. The genus *Cheirostrobus*, founded in 1897 by Dr. D. H. Scott on a single specimen of a petrified cone discovered in the rich volcanic beds of Lower Carboniferous age at Pettycur on the shores of the

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Firth of Forth, affords a striking illustration of a Palæozoic plant exhibiting a structure far more complex than that of any known type among existing Vascular Cryptogams. As Scott clearly shows in his admirable memoir, *Cheirostrobus* is a synthetic or compound genus, one of the numerous extinct types brought to light by the anatomical investigation of fossil plants, from which we have learnt more about the inter-relations of existing classes than we could ever hope to discover from the examination of recent species.

In this Scotch cone, about 3·5 cm. in diameter, we recognise Equisetaceous and Lycopodinous characters combined with morphological features typical of the extinct genus *Sphenophyllum*. Some specimens of vegetative stems described by Nathorst from Bear Island under the name *Pseudobornia*—characterised by their whorled leaves with fimbriate blades borne on nodal regions separated by long internodes—may, as Scott has suggested, represent the branches of the tree of which *Cheirostrobus* was the cone. Both Devonian and Culm rocks have furnished many examples of Lycopodinous plants. The genus *Bothrodendron*, closely allied in habit to *Lepidodendron*, has been recorded from Bear Island, Ireland, and Australia, and the cuticles of a Lower Carboniferous species form the greater portion of the so-called paper-coal of Tula in Russia. *Lepidodendron* itself had already attained to the size of a forest tree, with anatomical features precisely similar to those of the succeeding Coal period species.

Our knowledge of the ferns is not very extensive. The genus *Archæopteris* from Ireland, Belgium, Bear Island, and North America has always been regarded as a fern, but we must admit the impossibility of accurately determining its systematic position until we possess a fuller knowledge of the reproductive organs and of its anatomical structure. Similarly the genera *Rhacopteris*, *Adiantites*, and *Rhodea*, with other characteristic members of the Lower Carboniferous vegetation, may be provisionally retained among the oldest known ferns. The genus *Cardiopteris*—a plant with large oblong or orbicular pinnules borne in two rows on a stout rachis—is known only in a sterile condition, and it is quite as likely that its reproductive organs may have been of the Gymnospermous as of the Filicinean type.

Renault has described under the name *Todeopsis* some petrified sporangia which appear to be practically identical with those of existing Osmundaceæ, and a new Devonian genus *Cephalotheca* has been instituted by Nathorst for fertile specimens of a strange type of plant which he refers to the Marattiaceæ. Of much greater importance than the sterile fernlike fronds, which cannot be assigned with confidence to a definite position, are the petrified remains of stems and leaves of such plants as *Heterangium*, *Lyginodendron*, *Calamopitys*, and others which demonstrate the existence of a class of synthetic genera combining Filicinean and Cycadean characters. These plants are of exceptional interest as showing beyond doubt that Ferns and Cycads trace their descent from a common ancestry. Some of the supposed ferns from Lower Carboniferous rocks are known to have been fronds borne on stems with the structure of cycads, and we have good reason for believing that some at least of the gymnospermous seeds of Palæozoic age are those of plants of which the outward form was more fernlike than cycadean. The announcement made a few months ago by Professor Oliver and Dr. Scott that they had obtained good evidence as to the connection of the gymnospermous seed known as *Lagenostoma* with the genus *Lyginodendron* is one of the most important contributions to botany published in recent years; if, as I firmly believe, the evidence adduced is convincing, it gives satisfactory confirmation to suspicions that previous discoveries led us to entertain. The fact demonstrated is this: the genus *Lyginodendron*, a plant known to have existed during the greater part of the Carboniferous epoch, possessed a stem of which the primary structure was almost identical with that which characterises some recent species of Osmundaceæ, while the secondary wood produced by the activity of a cambium is hardly distinguishable from the corresponding tissue in the stem of a recent cycad. The fronds were those of a fern, both in the anatomy of their vascular tissue and in their external form; as far, therefore, as the vegetative characters are concerned, we have a combination of ferns and cycads. We still lack complete knowledge of the nature of the reproductive organs, but it seems clear that *Lyginodendron* bore

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I. *Devonian and Lower Carboniferous Floras.—Table showing the Geographical Distribution of a few Characteristic Genera.*

Characteristic Types	Arctic						N. Temperate			N. Sub-tropical				Tropical			S. Sub-tropical			S. Temperate		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Arohæocalamites radiatus				×			×	×									×		×			
Calamites								×														
SPHENOPHYLLALES																						
Sphenophyllum				×				×														
Cheirostrobus								×														
LYCOPODIALES																						
Lepidodendron				×				×									×	×	×			
Bothrodendron				×			×	×											×			
FILICALES (?)																						
Arohæopteris				×			×	×											×			
Adiantites				×			×	×														
Rhacopteris								×									×		×			
Rhodea				×				×														
Cardiopteris				×				×														
CYCADOFILICES																						
Lyginodendron								×														
Heterangium								×														
CORDAITALES																						
Cordaites							–					–					–					

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seeds constructed on the Gymnospermous plan, but characterised by an architectural complexity far beyond that represented in the seeds of any modern Conifer or Cycad.

In such genera of Gymnosperms as *Cordaites*, *Pitys*, and others, we have examples of forest trees possessing wood almost identical with that of existing species of *Araucaria*, but distinguished by certain peculiarities which point to a relationship with members of the Cycadofilices, and suggest that Conifers as well as Cycads may have sprung from a filicinean stock.

These waifs and strays from the vegetation of an era incredibly remote, when strange amphibians were lords of the animal world, afford, as Newberry expresses it, 'fascinating glimpses of the head of the column of terrestrial vegetation that has marched across the earth's stage during the different geological ages.'

Two facts stand out prominently as the result of a general survey of what are practically the oldest records of plant-life. One is the abundance of types which cannot be accommodated in our existing classification founded solely on living plants.

The Devonian and Lower Carboniferous plants lead us away from the present along converging lines of evolution to a remote stage in the history of life; they bring us face to face with proofs of common origins, which enable us to recognise community of descent in existing groups between which a direct alliance is either dimly suggested or absolutely unsuspected if we confine our investigations to modern forms. We recognise, moreover, in such a plant as *Archæocalamites* an ancestor from which we may derive in a direct line the existing members of the Equisetales. In other types, by far the greater number, we see striking examples of Nature's many failures, which, after reaching an extraordinary complexity of organisation, gave place to other products of evolution and left no direct descendants.

Another fact that seems to stand out clearly is the almost worldwide distribution of several characteristic Lower Carboniferous plants. The accompanying table (page 830), based on the artificial divisions marked out on the map, to which reference has already been made, shows how widely some of the plants had migrated from an unknown centre far back in a still more remote age. We are, as yet, unable to follow these Devonian plants to an earlier stage in their evolution. We are left in amazement at their specialised structure and extended geographical distribution, without the means of perusing the opening chapters of their history.

Upper Carboniferous (Coal-Measures) and Permian Floras.

From the Lower Carboniferous formation we pass on to the wealth of material afforded by the Upper Carboniferous and Permian rocks. From the point of view of both botanists and geologists, the fossil plants obtained from the beds associated with the coal are of greater interest and importance than those of any other geological period. By a fortunate accident our investigations are not restricted to the examination of carbonaceous impressions and sandstone casts left by the stems and leaves of the Coal-period plants. By means of thin sections cut from the calcareous nodules of the coal-seams of Yorkshire and Lancashire, and from the silicified pebbles of France and Saxony, it is possible to make anatomical investigations of the coal-forest trees with as much accuracy as that with which we can examine sections of recent plants. The differences between the vegetation that witnessed the close of the Carboniferous era and that which flourished during the opening stages of the succeeding Permian epoch are comparatively slight. It has been demonstrated by Grand'Eury, Kidston, Zeiller, Potonié, and others, that it is possible both to separate the floras of the Coal-measures from those of Lower Permian age, and to use the plant species as trustworthy guides to the smaller subdivisions of the Coal-measures; but apart from these minor differences, the general facies of the vegetation remained fairly constant during the Upper Carboniferous and Lower Permian periods.

The vast forests of the Coal age occupied an extensive area of land on the site of the present United States of North America, stretching across Europe into

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Eastern Asia; under the shade of their trees lived 'the stupid, salamander-like Labyrinthodonts, which pottered with much belly and little leg, like Falstaff in his old age.' The plants of these Palæozoic forests seem to be revivified, as we subject their petrified fragments to microscopical examination. Robert Louis Stevenson has referred to a venerable oak, which has been growing since the Reformation and is yet a living thing liable to sickness and death, as a speaking lesson in history. How much more impressive is the conception of age suggested by the contemplation of a group of Palæozoic tree-stumps exposed in a Carboniferous quarry and rooted where they grew! An examination of their minute anatomy carries us beyond the mere knowledge of the internal architecture of their stems, leaves, and seeds; it brings us into contact with the actual working of their complex machinery. As we look at the stomata on the lamina of a leaf of one of those strange trees, and recognise a type of structure in the mesophyll-tissues which has been rendered familiar by its occurrence in modern leaves, it requires but little imagination to see the green blade spreading its surface to the light to obtain a supply of solar energy with which to extract carbon from the air. We can almost hear the murmur of plant-life and the sighing of the branches in the wind as the sap courses through the wood, and the leaves build up material from the products of earth and air; products that are to be sealed up by subsequent geological changes, till after the lapse of countless ages the store of energy accumulated in coal is dissipated through the agency of man.

The minute structure of the wood of the Calamites, Lycopods, and other trees, agrees so closely with that of existing types that we are forced to conclude that these Palæozoic plants had already solved the problem of raising a column of water more than 100 feet in height. The arrangement of the strengthening or mechanical tissues in the long flat leaves of *Cordaites* is an exact counterpart of that which we find in modern leaves of similar form. The method of disposition of supporting strands in such manner as to secure the maximum effect with the least expenditure of material, was as much an axiom in plant architecture in the days of the coal-forests as it is now one of the recognised rules in the engineer's craft.

We need not pause to discuss the various opinions that have been expressed as to the conditions under which the forests grew; we may adopt Neumayr's view, and recognise a modern parallel in the moors of the sub-arctic zone, or find a close resemblance in the dismal swamp of North America. There is also the view expressed many years ago by Binney and warmly advocated by Darwin, that some at least of the Coal-period trees grew in salt-marshes, an opinion which receives support from several structural features suggestive of xerophytic characters recognised in the tissues of Palæozoic plants.

Time does not admit of more than the most cursory glance at the leading types of the Permo-Carboniferous floras. The general character of the preceding vegetation is retained with numerous additions. *Archæocalamites* is replaced by a host of representatives of the genus *Calamites*, an Equisetaceous type with stout woody stems and several forms of cones of greater complexity than those of modern Horsetails. Side by side with the Calamites there appear to have existed plants which, from their still closer agreement with *Equisetum*, have been described by Zeiller, Kidston, and others as species of *Equisetites*. The genus *Sphenophyllum*, a solitary type of an extinct family, was represented by several forms which, like the *Galium* of our hedgerows, may have supported their slender branches against the stems of stronger plants. Lycopods, with trunks as thick and tall as forest trees, were among the most vigorous members of the later Palæozoic forests. Although recent research has shown that several of the supposed ferns must be assigned to the Cycad-fern alliance, there can be no doubt that true ferns had reached an advanced state of evolution during the Permo-Carboniferous epoch. The abundance of petrified stems of the genus *Psaronius*, of which the nearest living representatives are probably to be found among the tropical Marattiaceæ, demonstrates the existence of true ferns. Others had more slender stems which clambered over the trunks of stouter trees, while some grew in the shade of *Lepidodendron* and *Cordaites*. The most striking fact as regards the Permo-Carboniferous ferns is the abundance of fertile fronds bearing sporangia which exhibit a more or less

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close agreement with those of the few surviving genera of Marattiaceæ. The more familiar type of sporangium met with in our existing fern-vegetation is also represented, and we have recently become familiar with several genera bearing sporangia exhibiting a close resemblance to those of modern Gleicheniaceæ, Schizæaceæ, and Osmundaceæ. The sporangial characteristics of the different families of living ferns are many of them to be found among Palæozoic types, but there is a frequent commingling of structural features showing that the ferns had not as yet become differentiated into so many or such distinct families as have since been evolved.

Prominent among the Gymnosperms of the Palæozoic forests must have been the genus *Cordaites*: tall handsome trees, with long strap-shaped leaves, recalling on a large scale those of the kauri pine of New Zealand. This genus, which has been made the type of a distinct group of Gymnosperms, combined the anatomy of an *Araucaria* with reproductive organs more nearly allied to the flowers of Cycads, and exhibiting points of resemblance with those of the Maidenhair-tree. It is not until the later stages of the Permo-Carboniferous epoch that more definite coniferous types made their appearance. The genus *Walchia*, in habit almost identical with *Araucaria excelsa*, the Norfolk Island pine, with *Ulmannia* and *Voltzia*, are characteristic members of the vegetation belonging to the later phase of the Permo-Carboniferous era. The Maidenhair-tree of the far East, one of the most venerable survivors in our modern vegetation, is foreshadowed in certain features exhibited by *Cordaites* and, as regards the form of its leaves, by *Psygmophyllum*, *Whittleseya*, and other genera. *Psygmophyllum* is known to have existed in Spitzbergen in the preceding Culm epoch, and *Wittleseya* occurs in Canadian strata correlated with our Millstone Grit. Leaves have been found in Permian rocks of Russia, Siberia, Western and Central Europe, referred to the genus *Baiera*, a typical Mesozoic type closely allied to *Ginkgo*. In the upper Coal-measures and lower Permian rocks a few pinnate fronds have been discovered, such as *Sphenozamites*, from the Permian of France, *Pterophyllum* from France and Russia, and *Plagiozamites* from the Permian of Alsace, which bear a striking likeness to modern Cycadean leaves. Throughout the Permo-Carboniferous era the Cycadofilices formed a dominant group; *Lyginodendron*, *Medullosa*, *Poroxylon*, and many other genera flourished in abundance as vigorous members of an ancient class which belongs exclusively to the past.

One distinctive characteristic of the vegetation of later Permo-Carboniferous days is the occurrence of the Cycad-like fronds already referred to; also the appearance of *Voltzia* and other conifers with species of *Equisetites*, pioneer genera of a succeeding era that constitute connecting links between the Palæozoic and Mesozoic floras.

What we may call the typical vegetation of the Coal-measures, which continued, with comparatively minor changes, into the succeeding era, flourished over a wide area in the northern hemisphere, suggesting, as White points out, an almost incredible uniformity of climate. The same type of vegetation extended as far south as the Zambesi in Africa, and to the vast coal-fields of China; it possibly existed also in high northern latitudes, but, since Heer's record of *Cordaites* in Novaya Zemlya in 1878, no further traces of arctic Permo-Carboniferous plants have been found. *Calamites*, *Lepidodendron* (with its near relative *Sigillaria*), Ferns, Cycadofilices, *Cordaites*, and other Gymnosperms, constitute the most familiar types. We have already noticed the existence in the southern hemisphere of Lower Carboniferous and Devonian genera identical with plants found in rocks of corresponding age within the Arctic circle. This agreement between the northern and southern floras was, however, not maintained in the later stages of the Palæozoic epoch. Australian plant-bearing strata homotaxial with Permo-Carboniferous rocks of Europe, have so far afforded no examples of *Sigillaria*, *Lepidodendron*, or of several other characteristic northern forms; in place of these genera we find an enormous abundance of a fern known as *Glossopteris*, a type which must have monopolised wide areas, suggesting a comparison with the green carpet of bracken that stretches as a continuous sheet over an English moor. With *Glossopteris* was associated a fern bearing similar leaves,

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known as *Gangamopteris*, and with these grew *Schizoneura* and *Phyllotheca*, members of the Equisetales. In addition to these genera there are others which bear a close resemblance to northern hemisphere types, such as *Noeggerathiopsis*, a member of the Cordaitales, and several species of *Sphenopteris*. Similarly, in many parts of India, *Glossopteris* has been found in extraordinary abundance in the same company with which it occurs in Australia. In South Africa an identical flora is met with which extends to the Argentine and to other regions of South America. A few members of this southern flora have been recorded from Borneo, and the genus *Glossopteris* is said to occur in New Zealand, but the latter statement has been called in question and requires confirmation. It is clear that from South America, through South Africa and India to Australia, there existed a vegetation of uniform character which flourished over a vast southern continent at approximately the same period as that which, in the northern hemisphere and in China, witnessed the growth of the forests whose trees formed the source of our coal-supply.

Since attention was drawn by Dr. Blanford and other writers to the facts of plant-distribution revealed by a study of the later Palæozoic floras, it has been generally admitted that during the Permo-Carboniferous era there existed two fairly well-marked botanical provinces. The more familiar and far richer flora occupied a province stretching from the western states of North America across Europe into China and reaching as far as the Zambesi; the other province was occupied by a less varied assemblage of plants, characterised by the abundance of *Glossopteris*, *Gangamopteris*, *Neuropteridium*, *Noeggerathiopsis*, *Schizoneura*, and other genera, stretching from South America through India to Australia.

Two questions at once suggest themselves: firstly, were these two botanical provinces defined by well-marked boundaries, or did they dovetail into one another at certain points? Secondly, is there any probable explanation of this difference between northern and southern floras, a feature not shown either by the preceding Devonian and Lower Carboniferous or by the succeeding Lower Mesozoic floras?

In Brazil, Professor Zeiller has recorded the occurrence of a flora including *Lepidophloios*, a well-known European member of the Lycopods, associated with such characteristic southern types as *Gangamopteris* and *Noeggerathiopsis*. Similarly from the Transvaal a European species of *Sigillaria*, with a Lepidodendroid plant, and another northern genus, *Psygmophyllum*, have been found in beds containing *Glossopteris*, *Gangamopteris*, *Noeggerathiopsis*, *Neuropteridium*, and other members of the so-called Glossopteris flora. In India, the Glossopteris flora exhibits an entire absence of *Lepidodendron*, *Calamites*, *Sigillaria*, and other common northern genera, while *Sphenophyllum* is represented by a single species. The Australian Permo-Carboniferous flora is also characterised by the absence of the great majority of the northern types. Until a few years ago the genus *Glossopteris* had not been discovered in Europe, but in 1897 Professor Amalitsky recorded the occurrence of this genus in association with *Gangamopteris* in Permian strata in Northern Russia.

We see, then, that in Brazil and South Africa the Glossopteris flora and the northern flora overlapped, but the former was the dominant partner. On the other hand, in rocks belonging to a somewhat higher horizon in Russia, we meet with a northern extension of the Glossopteris flora. The accompanying map (p. 835) serves better than a detailed description to illustrate the geographical distribution of these two types of vegetation in the Permo-Carboniferous era.

There is little doubt that the differences between the flora of the southern continent, that existed towards the close of the Carboniferous and during the succeeding Permian period, and that which flourished farther north have in some respects been exaggerated; geographical separation has played too conspicuous a part in influencing botanical nomenclature. Granting the existence of identical genera or representative types, there remains a striking difference between the two provinces into which the Permo-Carboniferous vegetation was divided. As regards an explanation of this fact, we can only hazard a guess; as Dr. Blanford and others have pointed out, there is a probable solution to hand. Briefly stated, the Upper Palæozoic plant-bearing strata of India, South America, Australia, and

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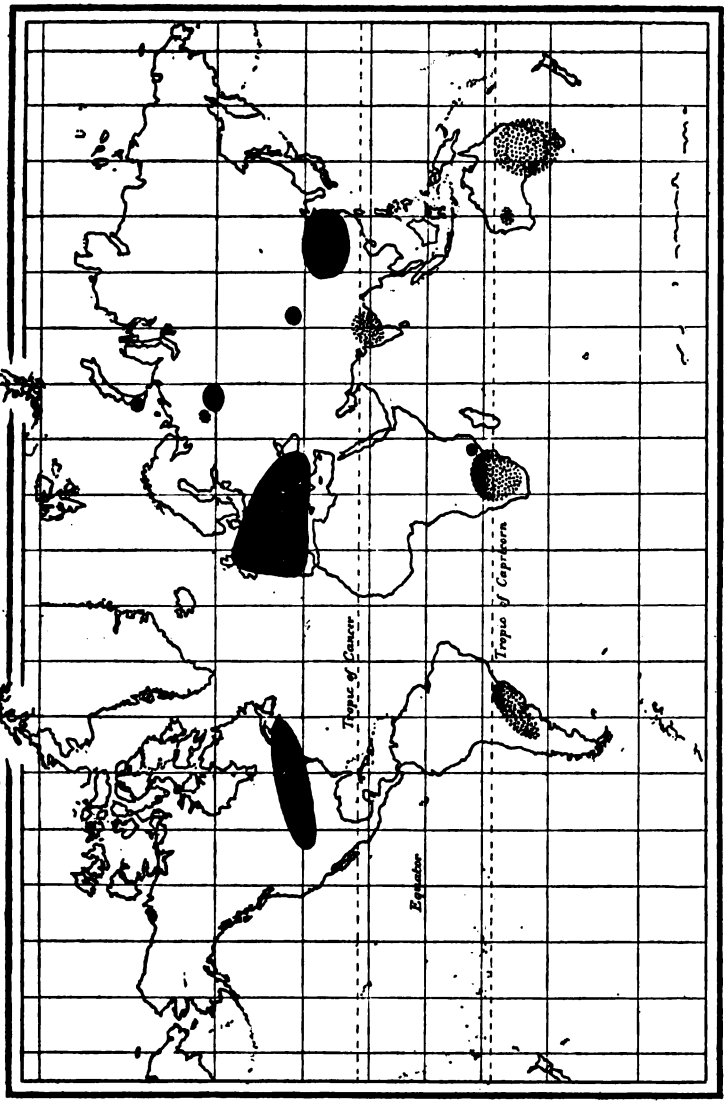
South Africa are in close association with boulder-beds of considerable extent. In some places, as for example in India and Australia, the boulder-beds rest on rocks bearing unmistakable signs of the grinding action of ice. There can be no reasonable doubt that the huge continental area of which India, South Africa,



MAP II.—Permo-Carboniferous Floras.

parts of South America, and Australia remain as comparatively insignificant remnants, was exposed to climatal conditions favourable to the accumulation of snow and to the formation of glaciers. One possible explanation, therefore, of the existence of a distinct vegetation in the southern area is that the climate was such as to render impossible the existence of those coal-forest plants that exhibited so vigorous

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a development in northern latitudes. There is, moreover, another consideration, and that is the effect on the vegetation of an enormous continental mass; in North America and Europe it is probable that the forests grew on low-lying land penetrated by lagoons and in part submerged under shallow brackish water, a disposition of land and sea very different from that in the so-called Gondwana Land of the South. Possibly the apparently uniform vegetation of the Devonian and Lower Carboniferous period was unable, through stress of climatal conditions, to prolong its existence in the southern area, while in the north it continued to flourish, and as the evolution of new types proceeded in rapid succession it was not slow to colonise new areas stretching in South America and South Africa to the confines of the Glossopteris flora.

There seems good reason for assuming that the Glossopteris flora originated in the South and before the close of the Permian period, as well as in the succeeding Triassic era, pushed northward over a portion of the area previously occupied by the northern flora. This northward extension is shown by the existence of *Glossopteris* in Upper Permian rocks of Russia, by the occurrence of several southern types in plant-bearing beds of the Altai mountains, and by the existence in Western Europe during the early stages of the Triassic era of such southern genera as *Neuropteridium* and *Schizoneura*.

Triassic, Jurassic, and Wealden Floras.

It is unfortunate that the records of plant-life towards the close of the Palæozoic and during the succeeding Triassic period are very fragmentary; the documents are few in number, and instead of the fairly continuous chapters in which the records of the Coal age have been preserved, we have to be content with a few blurred pages. During the Triassic period the vegetation of the world gradually changed its character; the balance of power was shifted from the Vascular Cryptogams, the dominant group of the Palæozoic era, to the Gymnosperms. It is not until we pass up the geologic series as far as the Rhætic formation, that we come to palæobotanical records at all comparable in their completeness with those of the Permo-Carboniferous era; but before considering the Rhætic vegetation we must glance at such scattered relics as remain of the vegetation belonging to the period of transition between the Palæozoic and Mesozoic facies. It is regrettable that this transitional period is unusually poor in documentary evidence that might throw light on the gradual change in the facies of Palæozoic vegetation. The new order, when once established, persisted for many succeeding ages without undergoing any essential alteration.

One of the few floras of early Triassic age of which satisfactory relics have been preserved is that described in 1844 by Schimper and Mougeot from the Bunter Sandstones of the Vosges. The genus *Neuropteridium*, a plant which may be a true fern, or possibly a surviving member of the Cycadofilices, is represented by a species which can hardly be distinguished from that which flourished in South America, South Africa, and India in the Permo-Carboniferous period. This genus and another southern type, *Schizoneura*, both of which are met with in the Triassic rocks of the Vosges, would seem to point to a northern migration of certain members of the *Glossopteris* flora, which took place at the close of the Palæozoic era. In the Lower Triassic flora Conifers are relatively more abundant than in the earlier periods; such genera as *Albertia* (resembling in its vegetative features some recent species of *Araucaria*), *Voltzia* (with cones that cannot be closely matched with those of any existing members of the Coniferæ), and other representatives of this class are common fossils. *Lepidodendra* have apparently ceased to exist; *Sigillaria* may be said to survive in one somewhat doubtful form, *Sigillaria oculina*. The genus *Pleuromeia*, which makes its appearance in Triassic rocks, is known only in the form of casts exhibiting a strong likeness to some Palæozoic Lycopods, and is perhaps more akin to *Isoetes* than to any other existing plant. The Calamites are now replaced by large Equisetaceous plants, which are best described as Horsetails with much thicker stems than those of their modern descendants.

From Recoaro in Northern Italy some of the Vosges genera have been recorded, and a few other European localities have furnished similar relics of a Triassic

vegetation. Passing to the peninsula of India, we find the genus *Glossopteris* abundantly represented in strata which there is good reason for regarding as homotaxial with the European Trias, and the occurrence in the same beds of some other genera of Permo-Carboniferous age shows that the change in the character of the southern vegetation at the close of the Palæozoic era was much more gradual than in the north.

The comparative abundance of plant remains in the northern hemisphere in rocks belonging to the Rhætic formation, a series of sediments so named from their development in the Rhætian Alps, is in welcome contrast to the paucity of the records from the underlying Triassic strata. From Virginia and adjacent districts in the United States a rich flora has been described, which by some authors is assigned to the Keuper or Upper Triassic series, while others class it as Rhætic. A similar assemblage of plants is known also from the Lettenkohle beds of Austria, which, as Stur has shown, clearly belong to the same period of vegetation as the American flora. We need not, however, concern ourselves with discussions as to the precise stratigraphical position of these American and European plant-beds, but may conveniently group together floras of Upper Triassic and Rhætic age since they exhibit but minor differences from one another. Plants of Upper Triassic or Rhætic age are known from Scania and Franconia in Europe, Virginia and elsewhere in North America, Honduras, Tonkin, Australia, South Africa, Chili, and other parts of the world.

The geographical distribution of plants of approximately Rhætic age is shown in the following table on p. 838, which demonstrates an almost worldwide range of a vegetation of uniform character. The character of the plant-world is entirely different from that which we have described in speaking of the Palæozoic floras. Gymnosperms have ousted Vascular Cryptogams from their position of superiority; ferns, indeed, are still very abundant, but they have undergone many and striking changes, notably in the much smaller representation of the Marattiaceæ. The Palæozoic Lycopods and Calamites have gone, and in their place we have a wealth of Cycadean and Coniferous types. As we ascend to the Jurassic plant-beds the change in the vegetation is comparatively slight, and the same persistence of a well-marked type of vegetation extends into the Wealden period. It is a remarkable fact that after the Palæozoic floras had been replaced by those of the Mesozoic era, the vegetation maintained a striking uniformity of character, from the close of the Triassic up to the dawn of the Cretaceous era. This statement is open to misconception; I do not wish to convey the idea that a palæobotanist would be unable to discriminate between floras from Rhætic and Wealden rocks; but I wish to emphasise the fact that in spite of specific, and to a less extent of generic, peculiarities, which enable us to determine, within narrow limits, the age of a Mesozoic flora, the main features of the vegetation remained the same through a long succession of ages. The accompanying tables (pp. 839, 840) illustrate the geographical distribution of some of the leading types of Mesozoic plants during the Jurassic and Wealden periods, and demonstrate not only the striking differences between the Mesozoic and Palæozoic floras, but also the much greater uniformity in the vegetation of the world during the Secondary era than in the preceding Permo-Carboniferous epoch.

Mesozoic Floras.

It may be of interest to glance at some of the leading types of Mesozoic floras with a view to comparing them with their modern representatives. We are so familiar with the present position of the flowering plants in the vegetation of the world, that it is difficult for us to form a conception of a state of things in the history of the plant-kingdom in which Angiosperms had no part.

a. *Conifers.*

How may we describe the characteristic features of Rhætic and Jurassic floras? Gymnosperms, so far as we know, marked the highest level of plant-evolution. Conifers were abundant, but the majority were not members of that group to which the best known and most widely distributed modern forms belong.

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II. *Rhætic Floras.—Geographical Distribution of a few Characteristic Types.*

Characteristic Types	Arctic						N. Temperate			N. Sub-tropical				Tropical			S. Sub-tropical			S. Temperate		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Equisetites Muensteri		×					×	×		×	×					×						
Equisetites arenaceus																						
Schizoneura								×			×	×				×		×				
Phyllotheca											×								×		×	
FILICALES																						
Clathropteris							×	×			×	×				×			×			
Dictyophyllum																						
Lacoopteris								×											×			
Todites		×					×	×			×	×				×			×		×	
Tæniopteris							×	×		×	×					×		×	×			
Thinnfeldia								×								×	×	×	×		×	
Sagenopteris							×	×											×		×	
CYCADOPHYTA																						
Cycadites							×	×								×						
Podozamites		×					×	×			×					×						
Otozamites								×		×	×			×		×						
Anomozamites								×			×			×		×						
Pterophyllum		×					×	×			×			×		×			×		×	
GINKGOALES																						
Baiera		×					×	×			×							×	×		×	
Ginkgo																						

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III. *Jurassic Floras.—Geographical Distribution of Characteristic Types.*

Characteristic Types	Arctic						N. Temperate			N. Sub-tropical				Tropical			S. Sub-tropical			S. Temperate		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Equisetites								×					×		×	×			×			
LYCOPODIALES																						
Lycopodites								×					×			×			×			
FILICALES																						
Cladophlebis denticulata							×	×	×	×			×			×			×			×
Coniopteris						×	×	×	×			×	×			×			×			
Dictyophyllum								×	×								×					
Klukia								×					×		×							
Laccopteris								×											×			
Matonidium							×	×														
Tæniopteris								×		×		×	×			×			×			×
Todites							×	×	×			×	×									
CYCADOPHYTA																						
Nilssonia						×		×	×			×	×			×						
Otozamites								×								×	×					
Podozamites						×	×	×	×	×		×	×			×			×			
Williamsonia							×	×				×				×						
GINKGOALES																						
Baiera / *Ginkgo*					×	×	×	×	×	×		×	×						×			
CONIFERALES																						
Araucarites								×								×			×			
Pagiophyllum							×	×		×		×			×	×						
Brachyphyllum								×							×	×	×		×			

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IV. *Wealden Floras.—Geographical Distribution of Characteristic Types.*

Characteristic Types	Arctic						N. Temperate			N. Sub-tropical				Tropical			S. Sub-tropical			S. Temperate		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
EQUISETALES																						
Equisetites							×	×					×									
FILICALES																						
Onychiopsis		×					×	×					×					×	×			
Matonidium							×	×														
Cladophlebis		×					×	×					×					×	×			
Sphenopteris							×	×										×				×
Weichselia							×	×					×									
Tæniopteris		×		×			×	×										×				
Laccopteris								×														
Gleichenites			×					×														
GINKGOALES																						
Baiera }		×		×	×		×	×														
Ginkgo }																						
CONIFERALES																						
Sphenolepidium		×					×	×														
Araucarites							×	×														
Pinites			×					×														
CYCADOPHYTA																						
Nilssonia								×					×					×				
Otozamites		×						×														
Zamites							×	×					×					×				
Bennettites							×	×														

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A comparison of fossil and recent conifers is rendered difficult by the lack of isfactory evidence as to the systematic position of many of the commoner types t with in Mesozoic rocks. There are, however, certain broad generalisations ich we are justified in making; such genera as the Pines, Firs, Larches, and her members of the Abietineæ appear to have occupied a subordinate position ring the Triassic and Jurassic eras; it is among the relics of Wealden and wer Cretaceous floras that cones and vegetative shoots like those of recent Pines cur for the first time in a position of importance. There are several Mesozoic nifers to which such artificial designations as *Pagiophyllum*, *Brachyphyllum*, d others have been assigned, which cannot be referred with certainty to a par- ular section of the Coniferæ; these forms, however, exhibit distinct indications a close relationship with the Araucarieæ, represented in modern floras by *raucaria* and *Agathis*. The abundance of cones in Jurassic strata showing the aracteristic features of those of recent species of *Araucaria* affords trustworthy idence as to the antiquity of the Araucarieæ and demonstrates their wide geo- aphical distribution during the Mesozoic era. At the present day the Arauca- eæ comprise the two genera *Araucaria* and *Agathis*, the former including ten ecies occurring in South America and Australia, and the latter comprising four ecies which flourish in the Malay Archipelago, New Zealand, the Philippines, orth-East Australia, and elsewhere. Sir William Thiselton-Dyer pointed out, a lecture on plant-distribution, delivered in 1878, that the genus *Araucaria* ppears to have been extinct in a wild state north of the Equator since the Jurassic poch. Additional confirmation of the important status of this section of the oniferæ is afforded by the abundance of petrified wood exhibiting Araucarian eatures, in both Jurassic and Wealden rocks. There is good reason to believe hat the well-known Whitby jet was formed by the alteration of blocks of Arau- arian wood drifted from forest-clad slopes overlooking a Jurassic estuary that ccupied the site of the moors and headlands of North-East Yorkshire. Among amiliar Jurassic genera, mention must be made of the genus *Brachyphyllum*, ncluding species referred by some authors to *Athrotaxites*, represented by frag- ments of leafy twigs and branches bearing a striking resemblance to those of the solated Tasmanian genus *Athrotaxis*. Omitting further reference to the various ndications afforded by a study of Mesozoic Conifers as to the former extension of many of the more isolated recent types, we may present in a tabular form an epitome of the past and present range of the Araucarieæ:—

Geographical Distribution of Past and Present ARAUCARIEÆ.

Araucarieæ	Arctic						N. Temperate			N. Sub-tropical			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Araucarites [Rhætic → Cretaceous]							×	×					
Araucaria 10 species													
Agathis 4 species													

Araucarieæ	Tropical			S. Sub-tropical			S. Temperate		
	14	15	16	17	18	19	20	21	22
Araucarites [Rhætic → Cretaceous]			×	×	×	×			
Araucaria 10 species				×		×			
Agathis 4 species			✓			×			×

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b. *Cycads.*

One of the most striking features of the Mesozoic vegetation is the abundance and wide distribution of Cycadean plants. To-day the Cycads or Sago-Palms are represented by ten genera and about eighty species; they are plants which occupy a subordinate position in modern floras, and occur for the most part as solitary types in tropical latitudes, never growing together in sufficiently large numbers to constitute a dominant feature in the vegetation. Cycads have long attracted attention as exhibiting morphological features of considerable interest. During the last few years the work of Ikeno, Webber, and Lang has shown us that the pollen of *Cycas*, *Zamia*, *Stangeria*, and probably of the other recent genera, produce spirally ciliated motile spermatozoids, the type of male cell previously regarded as constituting one of the well-defined distinctions between the Vascular Cryptogams and the Seed-bearing plants. The study of Palæozoic plants has done even more to break down the artificial barrier between Cycads and Vascular Cryptogams, by demonstrating beyond all reasonable doubt that our modern Cycads represent a small group of survivals descended from ancestors common to themselves and the ferns. Cycadean plants must have been among the commonest members of Mesozoic floras. Before the end of the Palæozoic era there existed plants bearing pinnate fronds similar to those of recent species of Cycadaceæ, and in succeeding ages the group rapidly increased in number and variety till, in the Jurassic and the early Cretaceous periods, the Cycads asserted their superiority as the leading type of vegetation. The majority of Mesozoic Cycadean fronds are assigned to artificial or form-genera as an indication of our ignorance of their reproductive organs, or of the anatomical structure of their stems. As Professor Nathorst has recently suggested, it is convenient to speak of these Cycadean remains as belonging to the group Cycadophyta. On the other hand, we find numerous petrified stems bearing well-preserved reproductive organs which enable us to compare the extinct with the existing species. We are in possession of enough facts to justify the statement that the majority of Mesozoic Cycads bore reproductive organs which differed in important morphological characters from those of existing forms. The researches of Williamson, Carruthers, Solms-Laubach, Lignier, and others, have revealed the existence of a large group of Cycadean plants—known as the Bennettiteæ—almost identical in habit with modern sago-palms, but distinguished by the complexity of their reproductive shoots. The Bennettiteæ, originally founded on a petrified stem discovered more than fifty years ago in the Isle of Wight, and represented by another fossil which Carruthers made the type of a new genus, *Williamsonia*, in 1870, possessed a thick stem, clothed with an armour of persistent leaf-bases and bearing a crown of pinnate fronds, as in most modern Cycads; but their flowers, which were borne on lateral shoots, were more highly specialised than those of the true Cycads. While most of the Mesozoic Cycads were no doubt members of the Bennettiteæ, others appear to have possessed reproductive organs like those of recent species. The Bennettiteæ belong to that vast army of plants that succumbed in the struggle for existence æons before the dawn of the Recent period. The other section of the Cycadophyta, the Cycadaceæ, still lingers on as one of the select band whose present insignificance constitutes a badge of ancient lineage, and a faint reflection of past supremacy.

The wealth of Cycadean vegetation during the latter part of the Jurassic and the earlier stages of the Cretaceous periods is admirably illustrated by the discovery in the Black Hills of North America, and in other districts of the United States, of hundreds of silicified trunks of Cycadean plants. The first discovery of petrified Cycadean stems in America was made by Tyson in 1859, who found two specimens in the Potomac beds of Maryland; since then more than 700 trunks, remnants of a vast Cycadean forest, have been obtained from the Black Hills alone. The investigations of Mr. Wieland, of Yale, who has been engaged for some time on the examination of this rich material, have already revealed the fact that in some of the Bennettiteæ the male and female organs were borne in a single flower, the female portion having a structure identical with that previously

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escribed from European stems, while the male flowers bear a close resemblance o the fertile fronds of a Marattiaceous fern. We have watched the progress of fr. Wieland's researches with keen interest and look forward to further important evelopments. With some of us, indeed, the feelings of the ideal student of cience are in danger of being overshadowed by a sensation akin to envy and a lesire to invade American territory.

c. *Ginkgoales.*

Before leaving the Gymnosperms a word must be said about another section—he Ginkgoales—represented by the Maidenhair-tree of China and Japan. *Ginkgo* or *Salisburia*) *biloba* has almost, if not quite, ceased to exist in an absolutely wild tate, but as a cultivated tree it has now become familiar both in America and Europe. The living Maidenhair-tree is in truth an anachronism, a solitary rem-nant that brings us into touch with a vanished world and appears as an alien among its modern associates. The abundance of fossil leaves, like those of *Ginkgo biloba*, and of other slightly different forms referred to the genus *Baiera*, associated not infrequently with remains of male and female flowers, demonstrates the ubiquitous character of the Ginkgoales during the Rhætic, Jurassic, and Wealden periods. In the Jurassic shales of the Yorkshire Coast, *Ginkgo* and *Baiera* leaves occur in plenty, some of them practically identical with those of the existing species. The abundance of fossil Ginkgoales in other parts of the world—in Australia, South Africa, South America, China, Japan, North America, Green-land, Franz Josef's Land, Siberia, and throughout Europe—demonstrates the former vigour of this class of plants, of which but one member survives. This type of Gymnosperm is distinctly foreshadowed in the Palæozoic vegetation, and as recently as the Eocene period a species of *Ginkgo*, indistinguishable in the form of its leaves from the living Maidenhair-tree, flourished in Western Scotland.

The accompanying table of distribution shows how extensive was the range of the Ginkgoales in the Mesozoic era—both geographically and stratigraphically.

Geographical Distribution of the GINKGOALES.

Ginkgoales	Arctic						N. Temperate			N. Sub-tropical			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Ginkgo } *Baiera* } [Rhætic → Cretaceous]		×		×	×		×	×	×			×	×
Ginkgo biloba												×	×

Ginkgoales	Tropical			S. Sub-tropical			S. Temperate		
	14	15	16	17	18	19	20	21	22
Ginkgo } *Baiera* } [Rhætic → Cretaceous]			×		×	×		×	
Ginkgo biloba									

d. *Ferns.*

Although many of the Mesozoic ferns are preserved only in the form of sterile fronds and are of little botanical interest, several examples of fertile leaves are known which it is possible to compare with modern types. The Polypodiaceæ,

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representing the dominant family of recent ferns, are met with in nearly all parts of the world and possess the attributes of a group of plants at the zenith of its prosperity. We may confidently state that so far as the somewhat meagre evidence allows us to form an opinion, this family occupied a subordinate position in the composition of Mesozoic floras. Polypodiaceous sporangia have been met with in Palæozoic rocks, and their existence during the Mesozoic period is not merely a justifiable assumption, but is demonstrated by the occurrence of undoubted species of Polypodiaceæ. It seems clear, however, that this family did not attain to a position of importance until the Mesozoic vegetation gave place to that which characterises the present period. The Osmundaceæ are now represented by five species of *Todea* and four of *Osmunda*; *Todea barbara* occurs in South Africa, Australia, Tasmania, and New Zealand, the other species are all filmy ferns and occur in New Zealand, New South Wales, New Caledonia, Samoa, and in a few other southern regions. The genus *Osmunda* has a wider range, occurring in Europe, Asia, North America, India, Japan, Southern China, Java, South Africa, and other parts of the world. During the Rhætic and Jurassic periods the Osmundaceæ flourished over the greater part of Europe; their remains have been recorded from England, Germany, Scandinavia, Russia, Poland, Siberia, and Greenland, also from North America, Persia, and China.

Similarly the Schizæaceæ, a family now represented by a few genera in India, North America, South America, Africa, Australia, Japan, China, and elsewhere, were among the more abundant ferns in the Jurassic vegetation. The Cyatheaceæ, a family that is now for the most part confined to the tropics, constituted another vigorous and widely spread section in the Jurassic period; we find them in Jurassic rocks of Victoria, as well as in several regions in Europe, North America and the Arctic regions.

The fertile fronds of many of the fossil Cyatheaceæ bear a striking resemblance to that isolated survivor of the family in Juan Fernandez—*Thyrsopteris elegans*. It is true that a considerable number of ferns of Jurassic and Wealden age have been described by the generic name *Thyrsopteris* without any adequate reason; but, neglecting all doubtful forms, there remain several types represented in the Jurassic flora of Siberia, England, and other parts of the world, which enable us to refer them with confidence to the Cyatheaceæ and to compare them more particularly with the sole existing species of *Thyrsopteris*. The Gleicheniaceæ, at present characteristic of tropical and southern countries, were undoubtedly abundant in the northern hemisphere in early Cretaceous days; abundant traces of this family are recorded from Greenland as well as from more southern European latitudes.

One of the most striking facts afforded by a study of the Mesozoic fern vegetation is the former extension and vigorous development of two families, the Dipteridinæ and Matonineæ, which are now confined to a few tropical regions and represented by six species. The tall graceful fronds of *Matonia pectinata*, forming miniature forests on the slopes of Mount Ophir and other districts in the Malay Peninsula in association with *Dipteris conjugata* and *Dipteris Lobbiana*, represent a phase of Mesozoic life which survives—

'Like a dim picture of the drowned past.'

The fertile fragment of a frond of *Matonidium* exposed by a stroke of the hammer in a piece of iron-stained limestone picked up on the beach at Hailburn Wyke (a few miles north of Scarborough), is hardly distinguishable from a pinna of the Malayan *Matonia pectinata*. Rhætic and Jurassic ferns referred to the genus *Laccopteris* afford other examples of the abundance of the Matonineæ in the northern hemisphere during the earlier part of the Mesozoic era.

The modern genus *Dipteris*, with its four species occurring in India, the Malayan region, Formosa, Fiji, and New Caledonia, stands apart from the great majority of Polypodiaceous ferns, and is now placed in a separate family—the Dipteridinæ. Like *Matonia* it is essentially an ancient and moribund type with hosts of ancestors included in such Rhætic and Jurassic genera as *Dictyophyllum*, *Camptopteris*, and others which must have been among the most conspicuous and

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vigorous members of the Mesozoic vegetation. The appended table illustrates in a concise form the former extension of the Matonineæ and Dipteridinæ :—

Geographical Distribution of the Matonineæ and Dipteridinæ.

Matonineæ and Dipteridinæ	Arctic						N. Temp.			N. Sub-tropical			
	1	2	3	4	5	6	7	8	9	10	11	12	13
MATONINEÆ													
Matonidium		×		×				×			×		
Laccopteris													
[Rhætic → Cretaceous]													
Matonia													
2 species													
DIPTERIDINÆ													
Dictyophyllum . .							×	×			×	×	
Camptopteris, &c. . .													
[Rhætic → Wealden]													
Dipteris													
4 species													

Matonineæ and Dipteridinæ	Tropical			S. Sub-tropical			S. Temperate		
	14	15	16	17	18	19	20	21	22
MATONINEÆ									
Matonidium						×			
Laccopteris									
[Rhætic → Cretaceous]									
Matonia									
2 species			×						
DIPTERIDINÆ									
Dictyophyllum . .									
Camptopteris, &c. . .			×	×		×			
[Rhætic → Wealden]									
Dipteris									
4 species			×						

Could we but question these survivors from the past, we should hear a tragic story of hopeless struggle against stronger competitors, and learn the history of their gradual migration from an ancient northern home to regions at the other end of the world.

e. *Flowering Plants.*

Our retrospect of the march of plant-life has so far extended to the dawn of the Cretaceous period, a chapter in geological history written in the rocks that constitute the Wealden series of Britain exposed in the Sussex cliffs and in the Weald district of south-east England. According to the geologist's reckoning, the Cretaceous period is of comparatively modern date; it occupies a position near the summit of a long succession of ages representing an amount of time beyond the power of imagination to conceive. On the other hand, to quote from Huxley's lecture on a piece of chalk, 'not one of the present great physical features of the globe was in existence. . . . Our great mountain-ranges, Pyrenees, Alps, Himalayas, Andes, have all been upheaved since the chalk was deposited, and the

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Cretaceous sea flowed over the sites of Sinai and Ararat.' This Cretaceous epoch, so recent geologically if measured by the standard of the antiquity of the everlasting hills, has a remoteness beyond our power to appreciate.

One interesting fact as regards the composition of the Jurassic Flora is the absence of any plants that can reasonably be identified as Angiosperms. In the Wealden flora of England no vestige of an Angiosperm has been found; this statement holds good also as regards Wealden floras in most other regions of the world. On the other hand, as soon as we ascend to strata of slightly more recent age we are confronted with a new element in the vegetation, which with amazing rapidity assumes the leading rôle. It is impossible to say with confidence at what precise period of geological history the Angiosperms appeared. When the rocks that now form the undulating country of the Weald were being accumulated as river-borne sediments on the floor of an estuary, this crowning act in the drama of plant evolution was probably being enacted.

'Nothing,' wrote Darwin to Sir Joseph Hooker in 1881, 'is more extraordinary in the history of the vegetable kingdom, as it seems to me, than the apparently very sudden or abrupt development of the higher plants. I have sometimes speculated whether there did not exist somewhere during long ages an extremely isolated continent, perhaps near the South Pole.' We date the appearance of a new product of evolution from the age of the strata in which it first occurs; but this may well be a misleading criterion: all that we can say is that at a particular period certain new types of organisms are brought within our ken.

To quote Darwin again: 'We continually forget how large the world is, compared with the area over which our geological formations have been carefully examined; we forget that groups of species may somewhere have long existed, and have slowly multiplied, before they invaded the ancient archipelagoes of Europe and the United States. We do not make due allowance for the intervals of time which have elapsed between our consecutive formations, longer, perhaps, in many cases than the time required for the accumulation of each formation.'

On another occasion Darwin wrote to his friend Hooker: 'The rapid development, as far as we can judge, of all the higher plants within recent geological times is an abominable mystery.' Such evidence as we possess, meagre as it admittedly is, shows that 'this overshadowing type of plant-life' no sooner appeared than it asserted itself with extraordinary vigour and created a revolution in the plant-world. Let us glance for a moment at the facts to be gleaned from an examination of the records of this critical period in the history of vegetation.

I have already pointed out that we have as yet recognised no Angiosperms in the Wealden floras of England, Spitzbergen, Germany, France, Austria, Belgium, Russia, and Japan; but from plant-bearing rocks of Portugal, regarded as homotaxial with those which British geologists speak of as Wealden, the late Marquis of Saporta named a fragment of a leaf *Alismacites primævus*, a determination that, while possibly correct, cannot be accepted as conclusive testimony. In Virginia and Maryland there occurs a thick series of strata known as the Potomac formation from which a rich harvest of plant-remains has been obtained. Professor Lester Ward has recently shown that under this title are included several floras, some of which are undoubtedly homotaxial with the Wealden of Europe, while others represent the vegetation of a later phase of the Cretaceous era. From the older Potomac beds a few leaves have been assigned to Dicotyledons and referred to such genera as *Ficophyllum*, *Myrica*, *Proteæphyllum*, and others. Some of these may well be small fronds of ferns with venation characters like those of the Elk's Horn fern (*Platycerium*), while others, though presenting a close resemblance to Dicotyledonous leaves, afford insufficient data for accurate generic identification. In dealing with fossil leaves of the dicotyledonous type, we must not forget that the recent genus *Gnetum*—a gymnosperm of the section Gnetales—possesses leaves that may be said to be indistinguishable in form and venation from those of certain Dicotyledons. Before the close of the Potomac period these few fragmentary relics of possible Dicotyledons are replaced by a comparative abundance of

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specimens which must be accepted as undoubted Angiosperms. Previous to the discovery of the supposed Angiosperms in Wealden strata of Portugal and North America, the earliest record of an Angiosperm was represented by Heer's *Populus primæva* from Northern Greenland. This name was applied to a fragmentary specimen which may be a true dicotyledonous leaf. In 1897 Dr. White, of the Geological Survey of the United States, stated that additional examples of dicotyledonous leaves had been obtained during the visit of the Peary Arctic expedition to the well-known locality in Greenland where Heer's *Populus primæva* was discovered in the so-called Kome series. From strata known as the Atane beds, which rest on the Kome series, unmistakable Angiosperms have been collected in abundance.

Another indication of the sudden increase in the number of dicotyledons is furnished by the Dakota flora of the United States—in age somewhat more recent than the older Potomac beds. In these plant-beds it is stated that Angiosperms constitute two-thirds of the vegetation.

We may sum up the whole matter in a few words. There is some evidence of the existence of Angiosperms before the close of the Wealden period. It may be added that the Stonesfield Slate of England (a formation of approximately the same age as the Inferior Oolite plant-beds of Yorkshire) has afforded a single specimen of a leaf which in form and venation has as much claim to be referred to the dicotyledons as many of the leaves from Wealden rocks. These earliest records are, however, unsatisfactory, and the names assigned to them are often misleading. As soon as we ascend a stage higher in the geological series, not only do the Angiosperms at once become abundant, but the whole facies of the vegetation undergoes a striking change. The Gymnosperms, especially the Cycads, are ousted from a supremacy maintained through countless ages, and the vegetation becomes essentially modern. Many of the earlier angiospermous plants may be referred to existing genera and present no features of special interest from a phylogenetic standpoint.

One of our most pressing needs is a thoroughly critical revision of the late Cretaceous and earlier Tertiary floras, with the object both of determining the systematic position of the older Angiosperms and of mapping out with greater accuracy the geographical distribution of the floras of the world in post-Wealden periods. This is a task which is sometimes said to be impossible or hardly worth the attempt; the available evidence is indeed meagre, and much of it has been treated with more respect than it deserves, but it is at least a praiseworthy aim, not to say a duty, to take stock of our material and to compile lists of plants that may bear the scrutiny of experienced systematists. We are profoundly ignorant of the means by which Nature produced this new creation; we can only emphasise the fact that in the early days of the Cretaceous era a new type was evolved which no sooner appeared than it swept all before it, and by its overmastering superiority converted the past into the present.

Conclusion.

In conclusion, I would urge the importance of taking stock of our accumulated facts, and of so recording our observations that they may be safely laid under contribution as aids to broad generalisations. Detailed descriptions and the enumeration of small collections are a necessity, but there is danger of the student neglecting the application of his results to problems of far-reaching import. We may borrow a saying of a great artist in regard to attention to detail—'I see it, but I prefer to construct the synthesis.'

There is no more fascinating task than to follow the onward march of the plant-world from one stage to another and to watch the fortunes of the advancing army. We see from time to time war-worn veterans dropping from the ranks, and note the constant addition of recruits, some of whom march but a short distance and fall by the way; while others, better equipped, rise to a position of importance.

At long intervals the formation is altered and the constitution of the advancing

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and increasing host is suddenly changed; familiar leaders are superseded by newcomers who mark their advent by drastic reorganisation. To change the metaphor, we may compare the stages of plant-evolution to the records of changing architectural styles represented in Gothic buildings. The simple Norman arch and massive pier are replaced, with apparent suddenness, by the pointed arch and detached shafts of the thirteenth century; the latter style, which marked an architectural phase characterised by local variations subordinated to a uniformity in essential features, was replaced by one in which simplicity was superseded by elaboration, and new elements were added leading to greater complexity and a modification of plan. Similarly the Palæozoic facies of vegetation passes with almost startling suddenness into that which monopolised the world in the Mesozoic era, and was in turn superseded by the more highly elaborated and less homogeneous vegetation of the Cretaceous and Tertiary periods. In taking a superficial view of architectural styles we are apt to lose sight of the signs of gradual transition by which one period passes into the next; so, too, in our retrospect of the changing scenes which mark the progress of plant-evolution, we easily overlook the introduction of new types and the gradual substitution of new for old. The invention of a new principle in the construction of buildings is soon followed by its wide adoption; new conceptions become stereotyped, and in a comparatively few years the whole style is altered. As a new and successful type of plant-architecture is produced it rapidly comes into prominence and acts as the most potent factor in changing the facies of a flora. Making due allowances for the imperfection of the Geological record, we cannot escape from the conclusion, which is by no means opposed to our ideas of the operation of the laws governing evolutionary forces, that the state of equilibrium in the vegetable kingdom was rudely shaken during two revolutionary periods. The earlier transitional period occurred when Conifers and Cycads became firmly established, while for the second revolution the introduction of the Angiospermous type was mainly responsible. As in the half-effaced documents accessible to the student of architecture 'the pedigrees of English Gothic can still be recovered,' so also we are able to trace in the registers imprinted on the rocks the genealogies of existing botanical types.

In the course of this address I have given but scant attention to the lessons we have learnt and are still to learn as to the family-history of plants. As Professor Coulter says: 'The most difficult as well as the most fascinating problem in connection with any group is its phylogeny. The data upon which we base opinions concerning phylogeny are never sufficient, but such opinions usually stimulate research and are necessary to progress.'

We who attempt to read the records of the rocks may be tempted to magnify the importance of the work, but I do not hesitate to add that botanists as a whole have but half realised the fact that the study of living plants alone supplies but a portion of the evidence bearing on problems of plant-evolution. To ignore the facts that may be gleaned from the investigation of extinct types is like attempting to draw up a genealogy by merely questioning an individual without consulting the documentary evidence of registers and other chronicles.

Each successive stage through which the organic world has passed contains some relics of a preceding age; in comparing the chalk with the calcareous ooze now accumulating on the bed of the Atlantic, Carpenter expressed the partial agreement between the two deposits by saying that we are still living in the Cretaceous period. Dr. Moore's recent researches, demonstrating a striking resemblance between many of the molluscs of Lake Tanganyika and fossils preserved in the sediments of Jurassic seas, led him to describe some constituents of the fauna of this inland lake as so many 'lingering shadows of the past,' while Tanganyika itself is a dwindled remnant of a Mesozoic sea. Similarly our modern vegetation differs enormously from that of the Mesozoic era, yet in the sago-palms of the Tropics and in species of Malayan ferns we recognise proofs of the continuity of plant-types through successive ages. One stage is superseded by another, but some characteristic elements of each period persist into the next, carrying on the traditions of the past and demonstrating the futility of our system of classification

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a system in which we express the limitations of our knowledge, as we suit our convenience, by dividing into periods the history of geological and organic evolution.

'It is only our ignorance that fixes a limit, as the mist gathered round the mountain's brow makes us fancy we are treading the edge of the universe.'

The following Reports and Papers were read:—

1. *Report of the Committee on the Teaching of Botany in Schools.*
See Reports, p. 420.

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2. *Report of the Committee on the Investigation of the Cyanophyceæ.*
See Reports, p. 419.

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3. *Report of the Committee on Botanical Photographs.*
See Reports, p. 416.

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4. *Report of the Committee on the Respiration of Plants.*

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5. *The Development of the Ascocarp in Ryparobius.*
By B. T. P. Barker, *M.A.*

Pure cultures of a species of Ryparobius, occasionally found on wild-rabbit dung, were obtained from a single ascospore. The fungus grows vigorously on many artificial nutrient media, rabbit-dung, carrot, and potato. No true conidia are formed, reproduction being carried on by ascospores. The ascocarps are usually developed in old cultures, but their development step by step has been observed under the microscope in hanging-drop cultures from a portion of vigorously growing mycelium, suddenly starved by transference from beerwort to distilled water. The archicarp consists of a small coiled hypha, the ascogonium, and a slender hypha, arising from the next cell of the mycelium, and growing over to the tip of the ascogonium, which appears to be an antheridial branch. Fusion probably takes place. The ascogonium then divides into a number of cells, which branch, and eventually produce a varying number of asci. A pseudo-parenchymatous tissue is formed around the ascogonium by the growth of investing hyphæ, arising from the neighbouring cells of the hypha which bears the archicarp. This tissue forms the wall of the ascocarp. The ascogonium appears to be uninucleate at first, and immediately after contact with the antheridial branch contains two nuclei, either situated closely together or apparently fusing. Later most of the cells of the system of hyphæ, developed from the ascogonium, are uninucleate, but some contain two nuclei, which probably fuse and become the single nucleus of a young ascus. The ascus becomes multinucleate, the nuclei arrange themselves just beneath the wall of the ascus in the form of a hollow sphere, and the ascopores are then formed, each with one end pointing towards the centre and the other towards the wall of the ascus, the arrangement thus being radial. Very little periplasm is present in the zone of spore formation. Associated closely with the single nucleus of the young ascus is a structure of variable shape which has almost as strong an affinity for stains as the chromatin of the nucleus itself. This structure appears to be of the

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nature of a vacuole and to be intimately concerned with the nutrition of the nucleus, which at this time is of a remarkably large size. The number and size of asci in the ascocarps are very variable. Under favourable conditions as many as fifty have been counted, while in other instances only one is present. Nutrition seems to be the principal factor in this variation. The walls of the asci are usually thin, but desiccation causes a thickening, in some cases as much as 5 μ. The dehiscence takes place by a small cap or lid at the apex of the ascus, the spores being collected into a mass in this region and expelled explosively. The spores vary in number and in size in different asci. Normally more than two hundred are found, but as few as sixteen have been seen.

These results point to a close relationship between the genera Ryparobius and Thelebolus, the structure of the archicarp in the species here described being practically identical with that figured by Brefeld for the latter genus. Hence the position of Thelebolus among the Hemiasci, asserted by this author, is incorrect, and it must be regarded as a true Ascomycete.

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6. *Culture Experiments with Biologic Forms of the* Erysiphaceæ. *By* E. S. Salmon.

Within the last two years the existence of 'biologic forms' in the *Erysiphaceæ* has been definitely proved. The special restriction of infection-power is found not only in the conidial (*Oidium*) stage, but also in the ascigerous stage.

In the present paper the author gives the results of experiments, which show that the infection-powers of the conidia which obtain when uninjured growing leaves of a plant are inoculated become altered under certain cultural conditions when cut-off leaves are used. The experiments prove that under the above conditions (*a*) a 'biologic form' which in nature is restricted to the species of a certain genus of host-plants becomes capable of infecting species belonging to another genus, and (*b*) species of plants which are immune in nature are able to be infected.

Among a number of detailed experiments given the following may be mentioned to illustrate the above points: (*a*) The conidia of the biologic form of *Erysiphe Graminis* on wheat, which has been repeatedly proved to be unable to infect barley when sown on uninjured growing leaves of the latter, proved capable of doing so when sown on cut-off leaves under certain cultural conditions. (*b*) The two species of wheat, *Triticum dicoccum* and *T. monococcum*, are, under natural conditions, immune against the attacks of *E. Graminis*. Under the above-mentioned method of culture, however, the conidia of *E. Graminis* on wheat are able to infect both species, producing conidiophores and ripe conidia in six to seven days.

The author considers that it is possible that *in this change of infection-powers of biologic forms of parasitic fungi in consequence of injury to the host-plant* an explanation may be found of the sudden appearance of disease on plants hitherto immune. Attacks by animals, or injury by rain, frost, &c., may produce the same change in the leaf-cells of the host-plant as that brought about by the above method of culture, and consequently render susceptible to the attacks of a fungus plants otherwise immune.

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7. *Willow-canker.* *By* Professor T. Johnson, *D.Sc.*, *F.L.S.*

Considerable damage has been caused by a canker in an osier holt in the west of Ireland. The bark looks burnt and blistered at the canker-spot, shows black specks breaking through it, and gradually peels off leaving the wood exposed and sometimes shredded. The microscope shows abundant mycelium present in the pith as well as the rest of the shoot. The black specks are the perithecia of *Physalospora* (*Botryosphæria*) *gregaria*, Sacc., or in some cases the pycnidia of *Dendrophoma Therryana*, Sacc., which Saccardo thinks may be the spermogonium

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stage of *Physalospora*. A third form of fungus—a *Diplodina*—closely allied to *Diplodina salicis*, West, was also present. Infection experiments were also described.

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8. *On the Occurrence of* Ulva latissima *and* Enteromorpha compressa *in Sewage Effluents, and on Variations in the Composition of the Tissues of these and Allied Seaweeds.* *By* Professor LETTS, *D.Sc., Ph.D., and* J. S. TOTTON, *B.A.*

The view expressed by one of the authors in conjunction with another chemist,[1] that the growth of *Ulva latissima* in quantity in a given locality is a sign of sewage pollution, has received remarkable confirmation by the occurrence of the seaweed under very peculiar circumstances.

About a year ago it was observed that a green growth had made its appearance on the fragments of brick used as the filling material in one of the experimental contact beds (lower series) employed in the purification of the Belfast sewage, and that this growth had the appearance of one of the varieties of green seaweed at an early stage of development. By the spring of the present year the surface of the contact bed had become dotted with patches of *Ulva latissima*, several of which were a foot or two in diameter, and the fronds of the seaweed four or five inches in length.

At another part of the works, the sewage after treatment (by septic tank and subsequent double contact with filter beds) was allowed to flow into a shallow lagoon, and there another green seaweed, *Enteromorpha compressa*, developed in abundance.

The authors are of the opinion that the spores of these two species of *Algæ* must have found their way into the sewage by leakage of sea water into the system—a view which is strongly supported by the high proportion of chlorine present in the sewage—seventy parts per 100,000 being found as the mean of twelve determinations, whereas ordinary sewage contains only from six to ten parts.

The occurrence of these seaweeds under the conditions stated above induced the authors to study the chemical composition of their tissues with the view of ascertaining to what extent the latter would be modified by environment or food supply.

The following somewhat remarkable results have been obtained with the carefully washed and dried seaweeds:—

	Percentage of Nitrogen	Percentage of Ash
Ulva latissima—		
From the sewage contact beds	8·94	9·41
„ Belfast Lough	6·18	15·07
„ Larne Lough	3·01	29·00
Enteromorpha compressa—		
Growing in sewage effluent	7·44	16·65
„ „ Larne Lough	1·96	28·60
Enteromorpha intestinalis—		
From brackish ponds near Belfast	1·58	51·78
„ Larne Lough	1·61	—

The authors desire to express their thanks to Professor Gregg Wilson and to Mr. Thornton for their assistance in identifying and supplying them with some of the specimens employed in the above investigation.

[1] Letts and Hawthorne, *Proc. Roy. Soc. Edinburgh*, 1901, p 268, and *Brit. Assoc. Report*, 1900.

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9. *On the Colonisation of a Dried River-bed.* By Miss M. C. Stopes.

The stream under consideration ran through meadows into the Thames, just west of Northfleet, Kent. Its width was from 15 to 25 feet, locally widening to 40 or more, and there was an uninterrupted flow of 2 to 3 feet of clear water provided by a perennial spring in the chalk. Aquatic animals and plants abounded on the muddy bottom, and tangled masses of *Potamogeton, Callitriche, Ranunculus aquatilis*, &c., floated to the surface. On the sides and banks were growths of *Typha, Phragmites, Sparganium, Myosotis*, &c.

The supply of water was tapped in the winter and early spring of 1900–1 by the powerful pumps of a new waterworks, and by April 1901 all water had ceased to flow. By July the mud was firm enough to walk on, and was broken at short intervals by cracks 6 inches across and several feet deep. Last year's plants had left very few traces either in or on the mud. The only true aquatics still growing were *R. aquatilis* var. *trichophyllus*, which retained its divided leaves, one plant of which flowered, and *Lemna minor* living under an inch or two of mud. Of semi-aquatics there were:—

Few.	Considerable Numbers.	
	Scattered.	Dominant locally.
Caltha palustris.	*Alisma plantago.*	*Carex paludosa.*
Carex hirta.	*Carex riparia.*	*Epilobium hirsutum.*
Eupatorium cannabinum.	*Digraphis arundinacea.*	*Glyceria aquatica.*
Juncus articulatus.	*Iris pseud-acorus.*	*Helocciadium nodiflorum.*
„ *obtusiflorus.*	*Juncus communis.*	*Myosotis palustris.*
	Ranunculus sceleratus.	*Nasturtium officinale.*
	Rumex hydrolapathum.	*Phragmites communis.*
	Sparganium ramosum.	*Salix.*
	Scrophularia aquatica.	
	Typha latifolia.	
	Veronica anagallis.	
	„ *beccabunga.*	

Total frequent—twenty, of which eight were locally dominant.

Plants encroaching from land:—

Few.	Considerable Numbers.	
	Scattered.	Dominant locally.
Asparagus officinale (1 *plant*).	*Anthoxanthum odoratum.*	*Chenopodium Bonus-Henricus.*
Convolvulus sepium (1).	*Agrostis vulgaris.*	*Chenopodium alba.*
Dipsacus sylvestris.	*Bromus sterilis.*	*Equisetum palustre.*
Epilobium parviflorum.	*Glyceria distans.*	*Polygonum lapathifolium.*
Field pea (1).	*Holcus lanatus.*	*Urtica dioica.*
Papaver rhœas (2).	*Humulus lupulus.*	
Phalaris canariensis (2).	*Polygonum hydropiper.*	
Prunus communis.	„ *persicaria.*	
Sonchus arvensis.	*Rumex conglomeratus.*	
Trifolium repens (2).	„ *obtusifolius.*	
Vicia Cracca.	*Solanum dulcamara.*	
	„ *nigrum.*	
	Tussilago farfara.	

Total frequent—eighteen, of which five are locally dominant.

There were, also, a little thalloid hepatic and moss which never reached maturity, *Funaria hygrometrica*, one patch of *Botrydium granulatum*, and *Vaucheria* down the cracks. Notable scarcity of Compositæ and Leguminosæ, as of Bryophytes and Algæ.

1902.—At first slow increase in dominance of land plants except grasses; absence of *Alisma* and *Ranunculus aquatilis*, *Lemna minor* still alive under

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the mud sheltered by nettles. By September great increase of land plants, solid jungle-like growths 3 to 5 feet high.

1903.—Heavy rains this year assisted the water plants; *Scrophularia* locally dominant, *Myosotis* very scarce; semi-aquatic tend to dominate in the open, *Urtica* largely where sheltered by willow; many grasses and *Epilobium*. Very mixed communities, e.g. *Urtica* and *Phragmites* struggling for dominance; *Phragmites* and *Carex* covered and nearly swamped by tangles of *Galium Aparine*; short *Helosciadium* and meadow grass forming a thick turf; hummocks of *Carex paludosa* covered by *Humulus Lupulus* and *Solanum dulcamara*.

The complete list shows eleven frequent semi-aquatics, of which four are locally dominant, as against thirty-two frequent land plants, of which eight are locally dominant.

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10. *The Botany of Upper Peru.* *By* A. W. Hill, *M.A.*

FRIDAY, SEPTEMBER 11.

The following Papers were read:—

1. *New Discoveries in Heredity.* *By* W. Bateson, *F.R.S.*

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2. *Results of some Cross-breeding Experiments with Plants.* *By* Miss Edith Saunders.

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3. *Recent Experiments in the Hybridisation of Orchids.* *By* Charles C. Hurst.

Recent Progress in Orchid Hybridisation.

First hybrid raised in 1856. One thousand three hundred distinct crosses in 1903. Two hundred and thirty generic hybrids. Majority of hybrids fertile. Hybrids of the fourth generation. Hybrids with pedigree of five distinct species. Orchid hybrids offer wide field to the student of inheritance.

Intermediate Hybrids.

Writer's experiments with *Paphiopedilum* (*Cypripedium*). First generation, S × I = SI; second generation, SI × B = BI + BS. Results apparently consistent with Mendel's Principles.

Dominant Hybrids.

Mainly confined to generic matings, e.g. *Sophronitis* × *Epidendrum* = *Epidendrum*. Infertile and cannot be tested in the light of Mendel.

False Hybrids.

Mainly confined to generic matings and all maternal, e.g. *Zygopetalum* ♀ × *Odontoglossum* ♂ = *Zygopetalum*; second generation gives same result. Therefore 'false hybrids' and not Mendelian 'dominants.' Writer's previous suggestion of parthenogenesis. Comparison with the paternal 'false hybrids' of Millardet and De Vries. Further experiments into the nature of one-sided inheritance urgently needed.

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4. *La fleur des Gnetacées.* *By* Professor Lignier.

5. *Parthenogenesis in* Gnetum ula. *By* Dr. Lotsy.

6. *The Sandhill Vegetation of Birkdale.* *By* Otto V. Darbishire.

The sandhills are formed by the wind blowing inland the sand, which is supplied by the sea.

Climatic conditions.—Rainfall of 31 inches; plenty of sunlight and heat during the day, rapid cooling during the night, heavy fall of dew; strong sea winds during the day, land winds at night, drying effect; sand not raised much by the wind.

Edaphic conditions.—Sand not very salty; loose grains, water soaks in and evaporates rapidly; isolating surface layer of dry hot sand-reefs, interior mass cool and moist; water derived from rain and internal dew; food material present.

Plant societies.—Shore dunes (*Agropyrum, Psamma*); shore valleys (*Honkenya*, &c.); inland dunes (*Psamma*); inland valleys on peat (*Parnassia*, &c.), and on sand (*Salix repens*, &c.). Moving dune front encroaching on grassland.

Common plant-features.—Rootstocks; xerophil leaves (types of *Psamma, Honkenya, Salix*, &c.); plants small; trees reduced in size, in dune form; plants in tufts.

Chief factors.—The sand and the wind. The plants are psammophytes, which vary with exposure to wind. The sandhills are therefore an edaphic formation. The dunes can be fixed by the binders, but temporarily only, till the supply of sand from the sea is cut off.

7. *The Histology of the Sieve Tubes of Angiosperms.* *By* Arthur W. Hill, *M.A.*

The paper deals with the structure and development of the sieve plate and of the sieve fields, and also with the distribution and character of 'connecting threads' between the sieve tubes and the companion and cambiform cells in the phloëm of certain Angiosperms. The sieve plates of the mature sieve tubes, which occur in the horizontal or oblique end walls of the tubes, are traversed by relatively thick slime strings, each being inclosed in a callus rod. In the radial and tangential walls the slime strings, which are grouped into oval or rounded pitted areas, are much smaller than those in the sieve plates, and some three to six strings are inclosed in a callus rod.

Connecting threads also occur between the sieve tubes and companion cells: they are very short and numerous, and are usually situated in fairly deep and transversely elongated pits. Between the sieve tubes and cambiform cells and between the latter and the companion cells the small groups of threads are found in small and deep pits.

During the winter these various threads may be covered with callus, but only on the sieve tube side. The development of the sieve fields is similar to that of the sieves of Pinus, and the sieve plates, though differing somewhat in the details of their development, agree in their essential features with the sieve fields.

Groups of fine threads can be seen in the membranes of the pits in the lateral walls of the youngest sieve tubes, which by the action of ferments (as it would seem probable) are bored out and converted into slime strings, the cellulose membrane in the immediate vicinity being at the same time converted into callus; and thus is formed the callus rod with its included slime strings.

In the sieve plates the action of the ferment appears to proceed still further, giving rise to a single large slime string in a callus rod.

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8. *The Structure of Leaves of the Bracken from different habitats.* By L. A. Boodle.

The external characters of the bracken (*Pteris aquilina*) vary with the habitat, as has been pointed out by different authors. In a very exposed and sunny situation the leaves are hard and short, while in a well sheltered and shaded locality they are much larger and soft. Long sori and short sori are typical of the first and second situation respectively.

The internal structure of the pinnules varies with the habitat in a corresponding manner; the presence of a continuous or nearly continuous hypoderm and the large amount of the palisade tissue formed distinguish the leaf of the exposed from that of the sheltered plant.

That these differences are not necessarily varietal is proved by the following observations. A leaf which had grown up through a fairly dense bush of hawthorn, bramble, &c., showed, in its lower pinnæ, which were immersed in the bush, the external and internal characters of the shade form, while the upper pinnæ, which were free from protection, had the characters of the exposed form. Secondly, the relation of the different characters in question to external conditions was also evidenced by a plant which was grown in a greenhouse (with heat) last year, and was planted out again in the autumn. In the greenhouse it produced only leaves of the shade type, of very delicate texture, and with the further peculiarity that both the indusia were often reduced in size. This year the same plant, growing in the garden, produced leaves of the type referred to above as characteristic of the bracken in an exposed situation.

Such formation of a mesophytic or a xerophytic type of leaf by the same plant in accordance with its environment is an example of what has been called 'direct adaptation,' and may be compared with Bonnier's experiments on transplantation to Alpine habitats and with the results of several authors on 'sun-leaves' and 'shade-leaves.'

MONDAY, SEPTEMBER 14.

The following Papers were read :—

1. *Discussion on the Evolution of Monocotyledons.*

i. *The Evolution of Monocotyledons.* By Ethel Sargant.

Monocotyledons and dicotyledons together form a group very distinct from any other, and the probability is strong that the common stock from which they spring was in all essential features Angiospermous.

Was the ancestral Angiosperm more like a monocotyledon or a dicotyledon—that is, which of these two types is the more primitive?

An answer to this question has been sought in three distinct lines of research, but these have led to no positive evidence in favour of either branch.

I. No direct historical evidence is given by the succession of fossil forms.

II. There is no reason to suppose the absence of a normal thickening ring in the stem of monocotyledons a primitive character.

III. The development of the embryo within the embryo-sac has not proved satisfactory as a guide to affinities.

The study of pseudo-monocotyledons such as *Corydalis cava*, *Ranunculus Ficaria*, *Carum Bulbocastanum*, has shown that the embryo within the embryo-sac in such species appears monocotylous from the first. Yet the common ancestor of each genus must have been dicotylous, and if the early history of the embryo-sac were any guide to race-history, we should expect it to throw light on the transition from a dicotylous to a monocotylous form.

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Embryological evidence of another kind has recently been brought forward to show that dicotyledons are the elder branch.

In the following paragraphs this evidence is set forth at some length under two heads:

(A) The nature and strength of the evidence itself.

(B) The support which the view it suggests receives from the mature characters defining monocotyledons.

(A) 1. The anatomy of the seedling soon after germination is often of value in the study of affinities.

My own observations have convinced me that within the Liliaceæ the symmetry of the vascular system in the cotyledon, hypocotyl, and primary root, is commonly characteristic of the genus, and is a valuable guide to the affinities of genera with each other.

(A) 2. The vascular symmetry of the single cotyledon in monocotyledons forms a sharp contrast with that of the first leaf. The bundles of the first leaf and those which succeed it are symmetrical about a true midrib. The bundle-system of the cotyledon is symmetrical about a pair of bundles, which may be distinct or partially united.

To this rule there are a few exceptions. But most of the cases in which the cotyledon seems to have a midrib can be connected through allied species with forms in which the bundle-system is bisymmetrical, and further work will probably link the few exceptional forms which remain with the double type.

(A) 3. The bisymmetrical vascular structure of the 'cotyledon' in monocotyledonous seedlings may be interpreted as the last trace of the double structure which arose from the gradual union of two ancestral cotyledons to form a single member.

This view is supported by:

(i) Comparative study of the Liliaceæ, which shows that—excluding species of exceptional habit—the many divergent schemes of vascular symmetry found among the seedlings of this family can be referred to a single type, in all probability the most ancient examined. In this type the two massive bundles of the cotyledon are quite distinct, and are symmetrically placed near the foci of its elliptical transverse section.

(ii) Evidence from the Amaryllidaceæ, Iridaceæ, and Aroideæ which tends to show that the structure of their seedlings is derived from a Liliaceous type.

(iii) Corroborative evidence from Palmæ and Scitamineæ to show the general absence of a midrib from the cotyledon. Several herbaceous species of Scitamineæ have two distinct and opposite bundles in their cotyledon.

(iv) Comparison with seedlings of Ranales, and particularly with the species, fairly numerous in this alliance, which have their cotyledons partially united. A single trace from each cotyledon enters the hypocotyl in the Ranal type. Each trace is clearly double, but the root is diarch. In the primitive Liliaceous type the two traces from the cotyledon enter the hypocotyl from opposite sides. Each opens out into a double structure during the transition. The root is tetrarch. Besides the resemblance in dual symmetry, I have perceived in *Eranthis* and *Podophyllum* a similarity to the Liliaceous type in the method of transition from stem to root, and in Eranthis the temporary appearance of a tetrarch xylem plate at the base of the tuber. The resemblance between the Ranal and Liliaceous type of seedling structure supports our hypothesis whether we consider it as homologous or homoplastic.

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(B) 1. The union of two ancestral cotyledons into a single member may have arisen from the adaptation of the earlier monocotyledons to a geophilous habit.
This view is supported by:

(i) Comparison with the dicotylous species in which the cotyledons are united for a considerable distance from the base upwards. With the single exception of the mangrove, these are all highly specialised geophytes. They all have a subterranean and greatly shortened vertical axis, which is often tuberous.

(ii) The fact that all dicotyledons with a single seed-leaf are well-marked geophytes.

(iii) The probability that the union of cotyledons is of service to the geophyte by reducing the expenditure of material in assimilating surfaces during the first year of growth. Such reduction is forced upon plants of this habit by the short season of growth in their native climate, and the prime necessity of forming underground organs before the beginning of the dead season.

(B) 2. Many features characteristic of mature monocotyledons can be explained as distinct adaptations to a geophilous habit, or as the necessary consequence of such adaptation.

(i) The linear leaves of bulbs, with their parallel venation and broad bases, are peculiarly adapted to rapid elongation and penetration of the soil.

(ii) The stem of monocotyledons shows many concentric circles of leaf-trace bundles. These are the almost inevitable consequence of the insertion on a squat axis of closely packed leaves with broad bases. From each leaf a number of parallel traces enter the axis in the segment of a circle.

(iii) The substitution of short-lived roots in immediate connection with the leaves, for a single branched tap-root is characteristic of low-growing plants exposed to alternating periods of activity and repose.

(iv) The formation of albuminous seeds, so general among monocotyledons, seems very commonly correlated with the geophilous habit in Dicotyledons. In geophilous species the embryo is usually small and little developed, probably because it has no time to grow larger in the short growing season. Such seeds usually require a long period of maturation before they germinate.

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ii. *A Consideration of the Bearing of Fertilisation Phenomena and Embryo Sac Structure on the Origin of Monocotyledons.* *By* ETHEL N. THOMAS.

There exists great uniformity among Angiosperms in these respects.
The development of the embryo sac shows it to be a megaspore.
Comparison with the germination of other megaspores shows that a great gulf exists between Angiosperms and all other groups of the vegetable kingdom. No distinction is found in this respect between monocotyledons and dicotyledons.
A few exceptional cases of embryo sac structure are known.

(*a*) Those in which normal productions arise from *less* than the usual number of constituents. Do these indicate what is essential to the process?
(*b*) Those in which normal productions arise from *more* than the usual components. Are these primitive?

The origin and modes of production of the Angiospermous endosperm are of

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peculiar interest. Their study has not as yet given any very reliable clue to its phylogenetic history.

These phenomena show no line of demarcation between monocotyledons and dicotyledons, but where differences exist between the Archichlamydeæ and the Sympetalæ, monocotyledons are connected in these particulars with the Archichlamydeæ.

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2. *On Stimulus and Mechanism as Factors of Organisation.* *By* Professor Farmer, *F.R.S.*

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3. *Alternation of Generations in the* Dictyotaceæ *and the Cytology of the Asexual Generation.* *By* J. Lloyd Williams.

1. The nuclei of the vegetative cells of tetrasporic plants have about thirty-two chromosomes in the karyokinetic figure.

2. In the stalk-cell division of the tetrasporangium the curved split chromosomes are easily counted and the unreduced number obtains.

3. In the tetraspore mother-cell there is a long period of preparation for division. A well-marked synaptic stage appears while the cell is still young and small. The thread is distinctly polarised and the nucleolus very irregular in form and frequently attached to the spirem. At this stage also, and at no other, the nucleus has a small deeply staining spherule. After a time the thread becomes thicker and less deeply stained, and it ultimately splits longitudinally. No clear evidence has been seen of a second split—probably the separating halves become greatly alveolated and connected together by cross-threads so as to present the appearance of the ordinary reticulum of the resting stage. This condition, during which the identity of the chromatin thread is completely lost, persists for a long time. Thick cloudy masses then appear, which gradually condense into sixteen chromosomes. These are bent upon themselves until the limbs are parallel, or cross each other, or form open rings.

The ensuing division is distinctly heterotype, and the spindle intra-nuclear.

4. The two daughter-nuclei in division have their axes parallel and the spindles are formed on the sides of the nuclei remote from each other. The division is homotype and the chromosomes show the reduced number.

5. In the germinating spore the chromosomes have been counted in the prophase, the equatorial plate, and the dispirem stages, and the number is always sixteen.

6. In the sexual plants, the dividing nuclei of the vegetative, antheridial, and oogonial cells are characterised by having the reduced number of chromosomes.

7. The curious abnormal figures found in unfertilised eggs show sixteen chromosomes, while the dividing nuclei of the germinating oospores always have the full number.

The cytological evidence then shows that the germinating tetraspore grows into a sexual plant, while the oospore on the other hand produces the tetrasporic generation. Furthermore, the reduction stage has all the distinguishing characters of the corresponding stage in the higher plants.

TUESDAY, SEPTEMBER 15.

The following Papers were read:—

1. *Modern Views on the Phylogeny of the* Algæ. *By* Dr. F. F. Blackman.

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2. *The new Botanical Laboratory at Cambridge.*
By Professor H. MARSHALL WARD, *F.R.S.*

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3. *The Seed of Lyginodendron.*
By Dr. D. H. SCOTT, *F.R.S.*, *and* Professor F. W. OLIVER.

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4. *Fruit-dispersal in* Adenostemma viscosum, *Forst.*
By R. H. YAPP, *M.A.*

Adenostemma viscosum is a Composite which is widely distributed in the warmer regions of the globe. The pappus in this plant is represented by several (usually three) stalked glands, by means of the secretion of which the ripe fruits are firmly attached to passing animals, and so dispersed.

During the time of flowering the gland-stalks are erect, and lie against the corollas of the florets. When the fruits are ripe, the corollas fall off *en masse*, being tied together by numerous filamentous hairs which clothe their upper extremities. The corollas and styles, as well as the ripe fruits, are cut off by special abscise mechanisms, which consist partly of fragile thin-walled parenchyma, and partly of thick-walled mechanical tissue. The involucral leaves are at first erect, then become spreading, and finally reflexed, while the receptacle becomes markedly convex. Thus the achenes, when ripe, are freely exposed. In the meantime the glands (which are composed of numerous capitate glandular hairs, thickly covering the upper parts of the pappus-setæ) have excreted a copious viscid fluid,[1] which causes them at this stage to bear a marked resemblance to the tentacles of a *Drosera* leaf. The pappus-setæ also bend down till they assume a nearly horizontal position, thus affording the three glands a more extended base by which to adhere. This movement is effected by a group of motor-cells which form a pulvinus at the base of the stalk of each gland.

Certain other Composites have also been examined, and it is found that the hygroscopic movements of the pappus is in some other cases (*e.g.* species of *Taraxacum*, *Tragopogon*, *Lactuca*, *Hypochoeris*, &c.) due to similar motor-cells, forming a continuous pulvinus situated just below the pappus.

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5. *On Homœomorphy among Fossil Plants.*
By E. A. NEWELL ARBER, *M.A.*

It is fully recognised that among recent plants species of different descent may possess many closely identical characters as the result of adaptation to particular conditions of the environment. Such xerophilous plants as *Cactus*, *Euphorbia*, and *Stapelia* are instances among many which might be quoted.

It is interesting to find that there is some reason to believe that similar instances of parallelism of development may be found among fossil plants. Attention has been called to this subject by recent progress in the study of fossil invertebrates. It has been pointed out by Mr. S. S. Buckman in regard to the Jurassic brachiopods, and by Messrs. Nicholson and Marr with reference to the graptolites, that species sprung from different stocks commonly exhibit 'the phenomenon of similarity in general with dissimilarity in detail,' and such have been termed by Mr. Buckman *homœomorphs*.

[1] The character of this secretion has not yet been examined, as only alcohol material has hitherto been available. Specimens of this plant are, however, now growing at the Cambridge Botanic Garden, from seed kindly sent by Mr. Macmillan of the Royal Botanic Gardens, Peradeniya, Ceylon; and it is hoped to decide this point in due course from fresh material obtained from this source.

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Among fossil plants the following genera and species exhibit the phenomenon of homœomorphy:—

Alethopteris and *Lonchopteris*	(Carboniferous).
Neuropteris heterophylla and *Linopteris Münsteri* .	,,
Neuropteris gigantea and *Linopteris sub-Brongniarti* .	,,
Otozamites and *Dictyozamites*	(Jurassic).
Glossopteris and *Gangamopteris?*	(Permo-Carboniferous).

6. *Methods of Mapping Plant Distribution.* *By* T. W. WOODHEAD.

WEDNESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *On some Anatomical Features of the Scutellum in* Zea Maïs. *By* ETHEL SARGANT *and* AGNES ROBERTSON.

The *epidermis* of the scutellum develops into a well-marked epithelium over the face which is in contact with the endosperm. We have found that this epithelium folds in on itself in places, forming narrow clefts of considerable depth in the dorsal surface. Both sides are of course lined with the epithelial layer, and the cleft is so narrow that they often touch each other. Traces of secretion are, however, commonly found within these structures which may fairly be described as glands. Their number and size vary in the individuals examined. Their distribution over the dorsal surface of the scutellum is also variable, but they are least frequent near the apex and in the regions bordering on the median longitudinal section; indeed, they are often quite absent from these parts. The glands are fully formed in the ripe seed, and we have not traced their development.

Similar glands are found in the allied genus *Coix*, but in the individuals of *C. lachryma-Jobi* which we examined they were less well developed than in *Zea*.

Vascular tissue.—The main bundle of the scutellum runs upwards to the apex from the level at which it is inserted on the stele of the axis. Just above its insertion this massive bundle is collateral, with some slight suggestion of a double structure. The single group of xylem is on the ventral side of the bundle. Higher up in the scutellum the xylem begins to creep round the phloëm, at the same time throwing out short branches consisting of tracheïds and albuminoid cells. Near the apex the main bundle becomes amphivasal, and slender branches are given off profusely from the dorsal face of the bundle. They penetrate all the tissue on the dorsal side of the scutellum apex, but are most frequent near the midrib. These little branches always end freely just under the dorsal surface, commonly about two rows of cells below the epithelium. In character they resemble the transfusion tissue described by Professor Weiss in Stigmarian rootlets.

We have not observed any relation between the terminations of the vascular branches and the epithelial glands. These terminations occur in those parts of the scutellum where the glands are least frequent.

2. *Experiments with the Staminal Hairs of* Tradescantia. *By* HAROLD WAGER.

If the staminal hairs or petals of the purple-flowered *Tradescantia virginica* be killed, either by heat or by certain fixing reagents, the coloured sap in the dead cells is at once taken up by the protoplasm, and especially by the nucleus, which becomes deeply stained red, blue, or greenish blue, according to the nature of the reagent used. The alcohols and corrosive sublimate give a blue or bluish-green coloration; acid alcohol or Pereny's fluid red, and if killed by heat the coloration is reddish violet.

Preparations thus made may be mounted permanently either in glycerine or

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Canada balsam. Petals of *Iris*, Vetch, or blue *Linum*, &c., do not give the same results. The coloured sap escapes from the cell as soon as the protoplast is killed. In *Tradescantia* it cannot escape so rapidly, owing apparently to the presence of a cuticularised membrane around each cell, and it consequently remains in contact with the nucleus a sufficiently long time to stain it. By means of this cuticularised membrane the penetration of fixing fluid appears to be to some extent prevented. The resistance of the cells to the action of reagents is, however, very variable. In methylated spirit the protoplasmic movement ceases in most cells at the end of 1½ minute, but was still observable in a few cells at the end of 2¾ minutes. In 3 minutes a large number of the nuclei had become stained blue. In 70 per cent. alcohol protoplasmic movement was visible in a few cells at the end of 11 minutes, but was very slow and had ceased altogether in 11½ minutes. In 70 per cent. alcohol, with a few drops of 5 per cent. solution of hydrochloric acid, the movement was visible in some of the cells at the end of 7 minutes; in Perény's fluid at the end of 17 minutes, but had entirely disappeared in 17½ minutes; in saturated solution of corrosive sublimate the movement stopped at once (in 15 to 30 seconds) in most cells, but was still visible in a few at the end of 2½ minutes, when it ceased altogether. In a 2 per cent. solution of potassium bichromate movement was observable 4 hours after immersion, and in two other cases for 2½ hours; in one case the hairs were placed in a small bottle of the solution. With a 1 per cent. solution of chromic acid movement was visible 1½ hour after the reagent was placed upon the hairs, and in the case of complete immersion of a few hairs in a bottle, 1 hour 25 minutes after immersion. The colour-changes which take place are: (1) The purple sap turns light blue, then greenish; (2) the nucleus and cytoplasm take up the stain; and finally (3) the colour disappears entirely, leaving only the brownish colour due to the reagent. In a 10 per cent. solution of ammonia the movement continues in some of the cells for 16 minutes. The colour-changes are interesting: (1) the sap first of all becomes light blue, with slow cytoplasmic movement; (2) dark blue, movement stopped, and coagulation taking place; (3) green, protoplasmic strands completely broken up, coagulation masses abundant; (4) bright green, cytoplasmic strands almost completely broken up and disintegrated. The nucleus remains colourless, and when the green colour begins to disappear, it is found at one end or on the side of the cell, surrounded by a thick layer of granules from the cytoplasm. It then begins to swell up, the sap becomes lighter and lighter in colour, and gradually disappears, and finally there is left in the cell only a colourless mass of disintegrated protoplasm.

Under normal conditions the flowers of *Tradescantia* last for one day only. They open early in the morning and begin to close up at night. This is accompanied by disintegration of the cells of the petals and stamens, which become converted into a pulpy mass in the course of about two days. The protoplasm is completely broken up in the majority of the cells, just as in the ammonia solution.

If, however, staminal hairs be taken from the flower in the middle of the day and placed in water, the disintegration of the cell does not take place for a much longer time, even after the cell is dead. The cells may remain in the living condition for several days. In one of my experiments a fairly brisk protoplasmic movement was visible in two or three cells twenty-four days after being placed in water. In the dead cells the nucleus is coloured green and remains so for several days.

Staminal hairs taken from an open flower later in the day (8 P.M.) already showed signs of disintegration, and in the course of two days had become completely disintegrated.

Hairs completely embedded in a layer of vaseline still showed protoplasmic movements in a few of the cells at the end of six days. In the dead cells the coloured sap could not escape, but the nucleus did not become stained, and in a very short time both it and the cytoplasm had become almost completely disintegrated. This seems to indicate that possibly the cell-sap plays some part in the rapid protoplasmic disintegration which takes place when the flower is in its pulpy condition. But further experiments are necessary before this can be satisfactorily determined.

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3. *On the Localisation of Anthocyan (red-cell sap) in Foliage Leaves.* *By* J. PARKIN, *M.A.*

There is an impression, the author believes, amongst botanists that the pigment known as anthocyan resides as a rule in the epidermis of the leaf. No extensive investigation seems to have been made to see how far this view is correct. The author has so far submitted to microscopical examination four hundred different instances of anthocyan occurring in foliage leaves. The species investigated include monocotylous and dicotylous trees, shrubs, and herbs, together with a few ferns. The anthocyan of leaves can be divided into four main categories:—

(1) *The transitory anthocyan of young leaves.*—This appears during the development of the leaf, disappearing again on maturity. It is a marked feature of tropical foliage, though it occurs less strikingly in many plants of temperate regions. Number of species so far examined, 235. The anthocyan is confined to the mesophyll in 64 per cent. of these, to the epidermis in 20 per cent., and is common to both in 16 per cent.

(2) *'Autumnal' anthocyan.*—This appears in many old leaves as they change colour previous to their fall. Number of species examined, 81. The anthocyan is confined to the mesophyll in 78 per cent. of these, to the epidermis in 11 per cent., and is common to both in 11 per cent.

(3) *The permanent anthocyan of mature leaves.*—This appears as the leaf matures, and persists throughout the life of the leaf as a *normal* character. This category includes (*a*) leaves with uniformly red lower surfaces; (*b*) leaves with definite pigmented areas in the form of spots, blotches, or zones; and (*c*) leaves of horticultural varieties, with coloured foliage. Number of species examined, 54. The anthocyan is confined to the epidermis in 70 per cent. of these, to the mesophyll in 17 per cent., and is common to both in 13 per cent.

(4) *The accidental anthocyan of mature leaves.*—In distinction from (3) this is not normally present in the mature leaves, but arises only under exceptional conditions, such as: (*a*) excessive insulation, followed by cool nights, seen in Alpine plants and in evergreens during winter; (*b*) the result of injury, a reddish zone often appears round a wound in a leaf; and (*c*) through the accidental exposure of the lower surface to the full rays of the sun. The greater sensitiveness of the under surface of the leaf to reddening is a fact of some interest and seems to have been unrecorded.

Thirty cases have been examined, and in the majority of these the anthocyan was confined to the mesophyll.

In summary, then, the anthocyan of young leaves and of autumnal leaves is usually confined to the mesophyll; that of mature leaves, when a normal feature to the epidermis, and when an exceptional one to the mesophyll. Thus the mesophyll, *i.e.* the chlorophyll cells, appears to be the usual, and, perhaps, the more primitive position for the red sap in leaves.

The fact that anthocyan is usually present only in the mesophyll of young leaves seems to weaken somewhat the view that its function there is to protect the chlorophyll by absorbing the destructive solar rays.

The author is inclined to think that the biological significance of this pigment has been overrated, and that the majority of cases may be capable of explanation on purely chemical or physiological grounds.

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4. *The Forest Resources of Australia available for British Commerce.* *By* E. T. SCAMMELL.

Forest conservation and development.—One of the most important duties requiring the early attention of the Federal Government of Australia is that of dealing with the forest resources of the Commonwealth. At present the forest laws and regulations in force, according to the judgment of the Victorian Royal

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Commission on Forestry (1901), are 'weak, unsystematic, and inefficient.' This has been acknowledged at different times by the various Governments of the Australian States, and desultory efforts to introduce some scheme of State regulation have been made, but no scientific and comprehensive plan, on the lines laid down by France, Germany, or India, has, apparently, been seriously considered or, at any rate, attempted. Referring to the need of forest conservation and management in Greater Britain, Professor W. Schlich says: 'Surely the time has come—or rather it came some time ago—for a more vigorous forest policy on sensible lines throughout the Empire. Let us strive to introduce systematic forest management, more particularly into Canada and Australasia.'

The labours of the Victorian Commission have resulted in a strong recommendation that the action of the Government of India should be followed by the legislatures of Australia, and a commission has been appointed for the purpose of obtaining information and of recommending measures for dealing with the forests in Western Australia.

The forest areas of Australia.—The magnitude and importance of the interests involved may be judged by the fact that the forest areas of Australia comprise 107,037,000 acres of marketable timber, or nearly half the areas of the forest lands of Europe, excluding Russia. Of these areas Queensland possesses about forty million acres, New South Wales twenty million, Victoria twelve million, South Australia four million, Western Australia twenty million, and Tasmania eleven million. To this should be added considerable areas in Queensland (over 100 million acres) and in Western Australia (over seventy million acres) covered with inferior timber, which has a local value for building and for general purposes.

Their nearness to the coast.—Most of the important forests of Australia are fairly accessible from the sea. This especially applies to the belts of jarrah and karri in Western Australia, and to Tasmania, whose forests of blue gum and stringy bark grow down to the shores of that island.

The commercial timbers of Australia.—The timbers of the Commonwealth are of many varieties, and some of them are of high commercial value. The chief of these, as shown in the great work of the late Baron von Mueller, are the eucalypts. Of this valuable timber alone there are over 150 species. Besides the eucalypts there are many kinds of casuarinas (the Australian oak), some conifers (the Moreton Bay pine, the cypress pine, the brown pine, or colonial deal, and others), many acacias (the Australian wattle), Banksias, and numerous other varieties.

At present, however, the range of Australian wood available for British commerce is limited. Western Australia and Tasmania are the only States that have seriously dealt with the question of exporting timber or of using their forest resources as a valuable commercial asset.

Conclusion.—My object in bringing forward at these meetings a practical subject of this nature is to aid, so far as one can, the efforts that are being put forth by scientific as well as commercial men to promote the interests of our colonies, the development and progress of which cannot fail to be of deep concern to the members of this Association. It will, I am sure, be readily granted that the more widely the products and the possibilities of our great colonial possessions are known, the more clearly will the fact be accentuated that our interests, whether scientific, industrial, or commercial, are one.

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5. *On the Preservation, Seasoning, and Strengthening of Timber by the Powell Process.* By Wm. Powell.

The timber to be treated is put into a solution of common sugar and water (or the refuse syrup of beet-sugar refining, with added water) and boiled in this solution until the air in the interstices of the timber is exhausted; the timber, still covered by the syrup, is allowed to cool down to 30° C. or less, by which time the air-spaces are filled with syrup. The timber is then removed and dried at a fairly high temperature in stores.

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The process is a very simple one, though naturally each particular kind of timber requires some modification of the process suited to its nature.

Numerous experiments have been made by independent authorities with, in many cases, astonishing results. The breaking strain of yellow pine had been increased from 50 to 100 per cent., and all timber so treated was improved in toughness and strength. Paving blocks of various kinds of timber had been processed and then soaked for fourteen days in water, when it was found that the 'Powellised' blocks only absorbed from one-fifth to one-half the quantity taken in by the natural wood.

Other interesting figures and details were given, and specimens of 'Powellised' and natural timber exhibited showing the change effected by the process in the various kinds of wood in daily use.

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6. *Plants on the Serpentine Rocks in the North-East of Scotland.* *By* W. Wilson.

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SECTION L.—EDUCATIONAL SCIENCE.

PRESIDENT OF THE SECTION.—SIR WILLIAM DE W. ABNEY, K.C.B., D.C.L., D.Sc., F.R.S.

THURSDAY, SEPTEMBER 10.

The President delivered the following Address:—

THE Section over which I have the honour to preside deals with every branch of education. It is manifest that in an Address your President cannot deal with all of them, and it remained for me to choose one on which I might remark with advantage. As my official work during the last thirty-three years has been connected with education in science, I think I cannot do better than take as my subject the action that the State has taken in encouraging this form of education, and show that through such action there has been a development of scientific instruction amongst the artisan population and in secondary day schools. The development may not indeed have been to the extent hoped for, but it yet remains that solid progress has been made.

I have chosen the subject deliberately, as I find that there are very few of those who have the interests of education strongly at heart, or who freely criticise those who have borne the burden of the past, that have any knowledge of the trials and difficulties (some of its own creating, but others forced on it by public opinion) which the State, as represented by the now defunct Science and Art Department, had to contend with in its unceasing missionary efforts in the cause of scientific instruction. I shall not attempt to do more than show that whatever its defect may have been in tact, whatever its shortcomings in method, that Department still deserved well of the country for the work that it did in regard to the fostering of scientific instruction in the country at large.

As far back as 1852 the Government of the day, influenced very largely by the Prince Consort, realised that it had an educational duty to perform to the industrial classes. Whether it was influenced by philanthropic motives or from the evidence before it that if Great Britain was to maintain its commercial and industrial supremacy scientific instruction was a necessity, it matters little. The fact remains that it determined that the industrial classes should have an opportunity of acquiring that particular kind of knowledge which would be of service to them as craftsmen. In this year 1852 the Speech from the Throne contained these words: 'The advancement of Fine Arts and of Practical Science will be readily recognised by you as worthy of a great and enlightened nation. I have directed that a comprehensive scheme shall be laid before you, having in view the promotion of those objects, towards which I invite your aid and co-operation.'

It is somewhat remarkable that the then Ministry, of which Lord Derby was the chief and Mr. Disraeli the Chancellor of the Exchequer, did not survive to promulgate the scheme, which proposed theoretical rather than practical science, but that their successors, under Lord Aberdeen, issued it and commenced to carry it into effect. In 1853 the Department of Science and Art was established under the direction of Mr. Cole. Since 1835 so-called Schools of Design had been in being. These came under the new Department, and it was

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determined to establish science classes for instruction in science, Dr. Lyon Playfair, the well-known chemist, being charged with the duty. Playfair resigned in 1858, and in 1859 Mr. Cole induced a young Engineer officer, Lieut. Donnelly, to undertake the inspection and organisation of science instruction throughout the country. It was through this officer's untiring energy and zeal that the classes in science flourished and were added to at this early stage of the new Department's history. The same energy was displayed by Donnelly during the whole of his long career in the service of the State, and I feel that it was fortunate for myself to have served so many years as I did under one to whom the country at large owes a deep debt of gratitude.

Not long ago he passed away from us, and there will be no more lasting memorial to him than that which he himself erected during his lifetime in the fostering that form of education which is of such vital importance to the national well-being.

To revert to history, I may record that the first science examinations conducted by the State took place in May 1861, and, the system of grants being made on the results of examination having been authorised, the magnificent sum of 1,900*l.* was spent on this occasion on the instruction of 650 candidates, that number having been examined. Thus early was the system of examination commenced in the Department's career, and the method of payments on the results of these examinations stereotyped for many years to come. There is reason to believe that the educational experts of that day considered that both were essential and of educational value, a value which has since been seriously discounted. Employers of labour in this country were not too quick in discerning the advantages that must ultimately ensue from this class of education if properly carried out and encouraged. Theoretically they gave encouragement, but practically very little, and this survives to some extent even to the present day. Some of the foremost employers, however, gave material encouragement to the formation of classes, insisting on their employees attending evening instruction; but conspicuous above all was Mr. Whitworth, who, in 1868, placed in the hands of the Department the sum of 100,000*l.*, to be devoted to the creation of scholarships, which were to be awarded at the annual May examinations. The proviso made by him was that all competitors were to have had experience in practical work in an engineering establishment. Such candidates, it was evident, must have found out their own weakness in education, and, by working in science classes, could make up their deficiencies, and the award of these scholarships would enable them to study further. Sir J. Whitworth was far-seeing and almost lived before his age, but the benefits that he has conferred, not only on individuals, but on science and industries, by his generosity will make his name to be remembered for generations to come. To have been a Whitworth scholar gives an *entrée* into various Government and engineering posts, and we have in the front rank of science men who have held these scholarships and whose names stand prominent in the development of engineering.

Incidentally, I may say that no country but this, for very many years, considered that instruction in science for the artisan was a large factor in maintaining and developing industry. The educational interests of the employer and the foreman were, in some countries, well provided for, but the mechanic was merely a hand, and a 'hand' trained in merely practical work he was to remain. He could not aspire to rise beyond. We may congratulate ourselves that such a 'caste' system does not exist amongst ourselves.

For the first twenty-five years of the Department of Science and Art the grants given by Parliament for science instruction were distributed almost entirely amongst those who were officially supposed to belong to the industrial classes, and no encouragement was offered to any higher class in the social scale.

It would take me too long to show that at first the industrial classes were very shy of seizing on the advantages offered them. Suffice it to say that they had to be bribed by the offer of prizes and certificates of success to attend instruction, and it was not for several years that the evening classes got acclimatised and became popular.

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The evening instruction was then largely attended by adults. That this was the case may be judged by the fact that the average age of candidates who obtained successes in advanced chemistry was about twenty-five and in elementary chemistry about twenty-one. I have alluded to the apathy displayed by employers and by the artisans in the early days of the Department of Science and Art. The causes which dispelled it in both employers and employed, in regard to science instruction, will be found in the following extract from a report by the Department of Science and Art:—

'The Paris Exhibition (1867) caused the work of this country to be brought into close comparison with that of the rest of the Continent, and in many points both of manufacture and of skilled labour it was found England did not stand in such a good position as she had done a few years back. Dr. Playfair, in a letter to the *Times*, drew attention to this, attributing much if not all the evil to the deficiency of our technical education among the artisan class. The substance of his letter was taken up by many persons of influence during the autumnal recess, and it led to a sort of educational panic, the cry for technical education becoming quite the absorbing topic among all circles and forming a considerable portion of the contents of all periodicals. Meetings were convened and addresses delivered all over the country, and the question was so much ventilated that important changes were anticipated in the educational arrangements of the country during the coming session of Parliament, which unfortunately were put off on account of the debates on the Reform Bill of 1868.

'The agitation necessarily brought forward the work of the Science Division of the Science and Art Department, and it is not a little remarkable how completely the system which had been growing up since 1860 seemed to meet all the requirements of the case, and at the same time how few persons had any idea of its provisions in spite of all that had been done to spread a knowledge of the scheme.

'There can be no doubt, however, but that this six years' work had silently, though materially, effected a change in the general tone of feeling on the subject of scientific education, and had been the means of preparing the country for the 1867 agitation. The different feeling among the working-classes on the subject was forcibly shown in the Annual Report of the Science and Art Department. From this it appears that in 1860 a pupil in one of the science classes in Manchester, a town usually looked upon as in advance of others, could hardly continue his attendance at the class owing to the taunts of, and ill-treatment by, his companions. Nevertheless, in the autumn of this year, 1867, hardly enough could be said or done to satisfy the desire for science classes being formed for those very persons who, but six years before, had considered attendance at a Government science school as almost against the rules of their trade.'

Such was the account of 1867 given by Mr. G. C. T. Bartley (now Sir G. Bartley, M.P.). The plan adopted by the Science and Art Department for encouraging instruction in science was perhaps the best that could be devised at the time, though we now know that it was capable of improvement. It may be mentioned that an improvement in it was made the next year by the introduction of a very large system of scholarships, scholarships which have enabled the possessors in some instances to continue their studies at universities, and several distinguished men owe their positions to this aid. It was in this same year that Mr. Whitworth established his scholarships, as before described.

I have endeavoured to give a brief *résumé* of what was done during the first fifteen years of the existence of the Science and Art Department, and it continued to expand its operations after 1868 on the same lines for another ten years. In 1876 your President became connected with the Department as a Science Inspector. I am sure the Section will forgive me if I am somewhat personal for a few moments. During the previous eight years I had had the honour of being a teacher of some branches of physical science at the School of Military Engineering, and my own training was such that I had formed a very definite opinion as to how science instruction should be imparted, both to those who had a good general education and also to those who had not. The method was the same in both cases: it should be taught practically. I may say that I had not

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myself had the advantage of being taught science at school; I had learned all I knew practically, and I entered the Department fully impressed with this view. Whenever possible I have till the present time endeavoured to impress this view on all who were interested in the work of the Department. Much of the science that was taught in State-supported classes was largely book work and cram, and the theoretical instruction as a rule was unillustrated by experiment. This was undoubtedly due to the system of payments being based on success at the examinations. I must here say that there were honourable exceptions to this procedure. There were teachers, then as now, who knew the subjects they taught, and who were inspired by a genuine love of their calling. I can in my mind's eye recall many such, some of whom have joined the majority and others who are still at work and as successful now as then in rousing the enthusiasm of their students.

I am not one of those who think, as some do, that cramming is entirely pernicious. A good deal of what used to be taught at public schools in my days was cram. It served its purpose at the time in sharpening the memory, and was a useful exercise, and it did not much matter if in after years much of it was forgotten. If the cramming is in science, a few facts called back to mind in after life are better than never having had the chance at all. In fact, as the faded beauty replied to the born plain friend, it is better to be one of the 'have beens' than a 'never wasn't.'

It was determined to make a vigorous onslaught against teaching that was unillustrated by experiment, and to encourage practical teaching as far as could be done. Proper apparatus for illustrating lectures was insisted upon, and, with aid from the Department, was eventually provided, though in some instances several years' pressure had to be exercised before it was obtained. I am bound to say that in many instances after it had been procured a surprise visit by the inspector during the hours of instruction often found that the lecture table was free from all encumbrance, and that the dust of weeks was upon the apparatus that should have been in use. This was sometimes due to the inability of the teacher to use the apparatus rather than to a wish to disregard the rules laid down by the Department; but usually it was due to the fact that the teacher found cram paid best. I should like to say here that this state of things does not exist at the present time, and that the training of science teachers by the Royal College of Science and by other institutions has completely broken down the excuses that were often offered at that time.

The first grants for practical teaching were paid for chemistry. The practical work had to be carried out in properly fitted laboratories. There were not half a dozen at the time which really answered our purpose, and one of the earliest pieces of work on which I was engaged was in assisting to get out plans for laboratory fittings. These were very similar to those which I had designed for the School of Military Engineering several years before. Thanks to the Education Act of 1870 (I speak thankfully of the work that some of the important School Boards have done in the past in taking an enlightened view of science instruction) there were some localities where the idea of fitting up laboratories was received with favour, and it was not long before several old ones were refitted, in which instruction to adults was given, and new ones established in Board Schools for the benefit of the Sixth Standard children. At that time an inspector's, like the policeman's, lot was not a happy one. We had to refuse to pass laboratories which did not fulfil conditions, though we left very few 'hard cases.'

Till after the passing of the Technical Instruction Act in 1887 the Department aided schools in the purchase of the fittings of laboratories (both chemical and others), and year after year this help, which stimulated local effort, caused large numbers of new laboratories to be added to the recognised list. After six or seven years we had a hundred or more laboratories at work of what I may call 'sealed-pattern efficiency.' I am not very partial to sealed patterns, but they are useful at times, for they tell people what is the least that is expected from them. The pattern was not without its defects; but laboratories, like other matters, follow the law of evolution, and the more recently fitted ones show that

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the experience gained whilst teaching or being taught in a sealed-pattern type has led to marked improvements. Personally I am of opinion that only necessaries should be required, and I rebel against luxuries; for a student trained by means of the latter will, as a rule, in after life fail to meet with anything beyond the mere essentials for carrying on his scientific work.

The sealed pattern is practically in abeyance, though it can be trotted out as a bogey, and any properly equipped laboratory is recognised so long as it meets the absolute necessities of instruction.

The half-dozen chemical laboratories which existed in 1877 have now expanded to 349 physical and 774 chemical laboratories. These are spread over all parts of England. I leave out Scotland and Ireland, as the science teaching is no longer under the English Board of Education.

It is only fair to say that many of this large number of laboratories are at present in secondary schools, regarding which I shall have to speak more at length. But the fact remains that in twenty-seven years there has been such a growth of practical science teaching that some 1,120 laboratories have come into being. My predecessor in the Chair likes to call laboratories 'workshops.' I have no objection, but the reverse; for the word 'laboratory,' like 'research,' sounds too magnificent for what is really meant, and all education should more or less be carried out in workshops.

The increase is as satisfactory as it is remarkable. It was only possible to increase the numbers in early days by gentle pressure and prophesying smooth things which, happily, did eventually come to pass. In later days the increase has been almost automatic. The Technical Instruction Act has called into being technical instruction committees who in many cases have taken up science instruction in their districts in earnest. They, too, have had public money to allocate, and not a little has gone in the encouragement of practical education. It may, however, be remarked that had it not been for the preliminary work that had been done by the Science and Art Department it is more than probable that the Technical Instruction Act of 1887 would never have seen the light.

A reference must now be made to the removal of what anyone will see was a great bar to the spread of sound instruction in every class of school where science was taught. So long as the student's success in examination was the test which regulated the amount of the grant paid by the State, so long was it impossible to insist on all-round practical instruction. It was impracticable to hold practical examinations for tens of thousands of students in some twenty different subjects of science. The practical examination in chemistry told its tale of difficulties. It was only when the Duke of Devonshire and Sir John Gorst in 1898 substituted for the old scheme of payments payment for attendance, and in a large measure substituted inspection for examination, that the Department could still further press for practical instruction. For all elementary instruction the test of outside examination does more harm than good, and any examination of the work done by elementary students should be carried out by the teacher, and should be made on the absolute course that has been given. It seems to be useless or worse that an examination should cover more than this. Instruction to a set syllabus which for an outside examination has to be covered spoils the teaching and takes away the liberty of method which a good teacher would enjoy. The literary work involved of answering questions, for an outside examiner, is also against the elementary student's success, and cannot be equal to that which may properly be expected from him a couple of years later.

Advanced instruction appears to be on a different footing. The student in advanced science must have gradually obtained a knowledge of the elementary portions of the subject, and it is not too much to ask him beyond the inspection of his work to express himself in decent English and submit to examination from an outside; but even here the payment for such instruction should be by an attendance grant tempered in some degree by the results of examination, since examiners are not always to be trusted.

The attendance grant was not viewed by some with great favour at first, and protests were received against its adoption, a favourite complaint being that it

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was sure to entail a loss of grant. One became suspicious that some of those who protested were aware that the last bulwark which defended the earning of grants by cram was being removed, and that inspection might prove more irksome than examination. This is past history now, and the new system works as smoothly as the old and with not more complaints than are to be always expected.

As I have said, grants were for very many years supposed to be confined to aiding the instruction of the industrial classes, but this limitation was more nominal than real. It might probably be imagined that it was no very difficult task to distinguish an artisan and his children from students who belonged to the middle classes. This was not the case, however. Children belonging to the industrial class were, on joining a science class, obliged to state the occupation of the father, and it was no uncommon thing for fathers to be given brevet-rank by their children. Thus, a bricklayer's son would describe his father as a 'builder,' which, if true, ought to have brought him into the ranks of the middle class. These unauthorised promotions were one of the difficulties the inspector had to face when judging as to the status of the parents. This difficulty was largely met by a rule that all those who attended evening classes were supposed to be of the industrial class; but as day classes increased the numbers of those who by no possibility could be of the artisan class also increased, and it became a very invidious duty of the inspector to put M.C. (Middle Class) against the names of many. It was determined by superior authority that only those students or their parents who could claim exemption from income-tax should be reckoned as coming within the category of industrial students. In early days the qualification for abatement on income-tax was a much lower figure than it is to-day, and almost each succeeding Chancellor of the Exchequer has raised the figure of the income on which the abatement could be claimed. To-day it is, I believe, 700*l.* a year, bringing the official definition as to membership of the industrial classes to an absurdity. It became evident to the official mind, which some people are good enough to say works but slowly, that the definition must be amended or the limitation abolished. The progress of events happily made the abolition the better plan, and was the means of allowing inroads of science instruction to be made into secondary day schools.

The history of these inroads I shall now give. Instruction given in so-called organised science schools was originally aided by the Department by means of a small Capitation Grant. These schools were supposed to give an organised course of science instruction, and the successes at examination determined the payment. They were not satisfactory as at first constituted, and they so dwindled away in numbers that in 1890 only some one or two were left. A small increase in Capitation Grant in 1892 revived some of them, and a fair number existed in the following year. There was no doubt, however, that the conditions under which they existed were most unfavourable for a sound education, which ought not only to include science but also literary instruction. The latter was, in many schools, wholly neglected, owing to the fact that the grants earned depended on the results of examination, and so all the school time was devoted to grant earning.

Mr. Acland, at this time Minister for Education, was made aware of this neglect to give a good general education, and as I was at that time responsible for science instruction I was directed to draw up a scheme for reorganising these schools and forcing a general as well as scientific education to be carried out. Baldly the scheme abolished almost entirely [1] payments on results of examination, and the rate of grant depended on inspection and attendance. Further, a certain minimum number of hours had to be given to literary subjects, and another minimum to science instruction, a great deal of it being practical and having to be carried out in the 'workshop.' The payments for science instruction were to be withheld unless the inspector was satisfied that the literary part of the education was given satisfactorily.

The scheme was accepted and promulgated whilst the Royal Commission on Secondary Education was sitting, and, if I may be allowed to say so, Mr. Acland's tenure of office would be long remembered for this innovation alone, since in it he

[1] Within the next four years they will entirely cease.

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took a wide departure from the traditional methods of the Department and created a class of secondary school which differed totally from those then existing. Needless to say the scheme was not received with favour on all sides, more especially by those who thought that serious damage would be done to secondary schools by the competition from this new development of secondary education. I am not ashamed to say that the disfavour shown on some sides made me rejoice, as it indicated that a move had been made in the right direction. At first it was principally the higher-grade Board Schools that came under the scheme, and in the first year there were twenty-four of them at work. This type of school gradually increased until about seventy of them, and chiefly of a most efficient character, were recognised in 1900. Their further increase was only arrested by the Cockerton judgment, now so well known that I need only name it. But here we come to a most interesting development. State aid, as already said, was at first limited to the instruction of the industrial classes, but no limitation as to the status of the pupil was made in this new scheme for the schools of science, and logically this freedom was extended in 1897 to all instruction aided by the Department—the date when all limitation as to the status of the pupil was abolished, the only limitation being the status of the school itself. Thus, if a flourishing public school, charging high fees for tuition, were to apply to participate in the grant voted by Parliament, it may be presumed, it would have to be refused. The abolition of the restriction as to the status of the pupils left it open to poorly endowed secondary grammar schools to come under the new scheme. To a good many the additional income to be derived from the grant meant continuing their existence as efficient, and for this reason, and often, I fear, for this reason alone, some claimed recognition as eligible.

Such is an outline history of the invasion of science instruction into certain secondary schools—an invasion which ought to be of great national service. In my view no general education is complete without a knowledge of those simple truths of science which speak to everyone, but usually pass unheeded day by day. The expansion of the reasoning and observational powers of every child is as material to sound education as is the exercise of the memory or the acquisition of some smattering of a language. I am not going into the question of curricula in schools, as I hope, regarding them, we shall have a full discussion. But of this I am sure, that no curriculum will be adequate which does not include practical instruction in the elementary truths of science. The President of the Royal Society, in his last Annual Address, alluded to the mediæval education that was being given in a vast number of secondary schools. Those who planned the system of education of those times deserve infinite credit for including all that it was possible to include. Had there been a development of science in those days, one must believe that with the far-seeing wisdom they then displayed they would have included that which it is the desire of all modern educationists to include. Observational and experimental science would have assuredly found a place in the system.

One, however, cannot help being struck by the broadening of views in regard to modern education that has taken place in the minds of many who were certainly not friendly to its development. Perhaps in the Bishop of Hereford, when headmaster of Clifton, we have the most remarkable early example of breadth of view, which he carried out in a practical manner, surrounding himself with many of the ablest teachers of science of the day. There are other headmasters who, though trained on the classical side, have had the prescience to follow in his footsteps, and of free will; but others there are who have neither the desire nor the intention, if not compelled to do so, to move in the direction which modern necessities indicate is essential for national progress. I am inclined to think that the movement in favour of modernising education has been very largely quickened by the establishment of schools of science in connection with endowed schools and the desire for their foundation by the Technical Instruction Committees, who had the whisky money at their disposal, and who often more than supplemented the parliamentary grants which these schools were able to earn. It was the circumstance that the new scheme was issued when many endowed schools were in low water that made it as successful as it has been.

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The number of schools of science increased so rapidly that it appeared there might be a danger of too many of this type being started on insufficient educational grounds. Science instruction was carried in them to such an advanced point and so many hours of the week were spent on it that they became in some degree specialised schools. At least eight hours a week had to be devoted to science, ten to literary instruction, and five to mathematics—any further time available could be spent on any section that was considered desirable. For some pupils the time devoted to science is barely enough, but for others who intend to follow careers in which the literary section should predominate it appeared that some curtailment of hours in the science section might be usefully allowed, and it became a question how far such instruction might be shortened without impairing its soundness. After much anxious thought it was considered that four hours per week, besides mathematics, was the very least time that ought to be devoted to such instruction, and that the latter part of it should be practical work. A scheme embodying this modification was approved by the Lord President and the Vice-President whilst I was Principal Assistant Secretary for Secondary Education, and smaller grants than those for schools of science were authorised in 1901 for those schools who were prepared to adopt it. By the scheme instruction has to be given only in such subjects and to such an extent as is really necessary to form part of that general education of ordinary students who might not have to follow in industrial pursuits. This modified and shortened course has met with unqualified success. Some 127 schools came under the scheme the first year, and I gather that there will be a considerable increase in numbers in the future. The establishment of schools of science and of these schools may be considered to be a great step taken in getting practical instruction in natural knowledge introduced into secondary schools. The leaven has been placed in some 300 of them, and we may expect that all schools which may be eligible for State aid will gradually adopt one scheme or the other. Though it is said that there is nothing in a name, I am a little doubtful as to whether the earmarking of science education as distinct from secondary education is not somewhat of a mistake at the present day. For my own part, I should like to think that the days have passed when such an earmarking was necessary or advisable. The science to be taught in secondary schools should be part and parcel of the secondary education, and it would be just as proper to talk of Latin and Greek instruction apart from secondary education as it is to talk of science instruction. One of the causes of the unpopularity of the Science and Art Department was its too distinctive name. At the same time it would be most unwise at the present time, when the new Education Committees are learning their work and looking to the central authority for a lead, for the State to alter the conditions on which it makes its grants to these schools. It will require at least a generation to pass before modernised education will be free from assault. If science instruction is not safeguarded for some time to come it runs a good chance of disappearing or being neglected in a good many schools. As to the schools which have no financial difficulties, it is hard to say what lines they may follow. Tradition may be too strong in them to allow any material change in their courses of study. If it be true that the modern side of many a public school is made a refuge for the 'incapables,' and is considered inferior to the classical side, as some say is the case, such a side is practically useless in representing modern education in its proper light. Again, one at least of the ancient universities has not shown much sympathy with modern ideas, and so long as she is content to receive her students ignorant of all else but what has been called mediæval lore, so long will the schools which feed her have no great inclination to change their educational schemes.

If we would only make the universities set the fashion the public schools would be bound to follow. The universities say that it is for the public schools to say what they want, and *vice versa*, and so neither one nor the other change. It appears to me that we must look to the modern universities to lead the movement in favour of that kind of education which is best fitted for the after life of the large majority of the people of this country. If for no other reason, we must for this one hail the creation of two more universities where the localities will be able to impress on the authorities their needs. The large majority of those whose

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views I share in this matter are not opposed to or distrust the good effects of those parts of education which date from ancient times. The great men who have come under their sway are living proofs that they can be effective now as they have been in times past, but we look to the production of greater men by the removal of the limitations which tradition sets. I myself gratefully acknowledge what the public school at which I had my early education did for me, but I think my gratitude would be more intense had I been given some small elementary instruction in that natural knowledge which has had to be picked up here and there in after life.

There is one type of college which I have not alluded to before, and that is the technical institutes. These have been fostered by the localities in which they are situated, and been largely supported by the whisky money, supplemented by Government aid. I am glad to see that in the last regulations of the Board of Education these colleges will receive grants for higher scientific instruction, and I have no doubt that in the near future such institutions and schools of science will receive a block grant, which will give them even still greater freedom than they now enjoy. These are colleges to which students from secondary schools will gradually find their way, where they wish for higher education of a type different from that to be gained at a university.

I have endeavoured to give a brief historical sketch of what the State has done in helping forward instruction in natural knowledge amongst the industrial classes, adults and children, and how gradually its financial aid has been extended to secondary schools. I have also endeavoured to indicate the steps by which practical instruction has been fostered by it. I have done this because I am confident that ninety-nine educationists out of every hundred have but little idea what the State has been doing for the last fifty years. Some connected with secondary schools—I have personal knowledge—were till lately ignorant that the State had offered advantages to them of a financial nature. I may say that the work of the late Science and Art Department was largely a missionary work. It was abused, sometimes rightly but more often wrongly, for this very work, and it had more abusers at one time probably than any other Government Department. Even friends to the movement of modernising education found fault with it as antiquated and slow, but I can assure you that no greater mistake can be made in pressing forward any movement by any hurried change of front or by endeavouring to push forward matters too rapidly. In the first place, the Treasury naturally views untried changes with suspicion, and this fact has to be dealt with more particularly when there is no great expression of public opinion to reckon with. At the same time it cannot be stated too strongly that the Treasury has in recent years dealt in a friendly and enlightened spirit with all matters which could affect the spread of science. Again, there is a hostility to great and rapid changes in the minds of those whom such changes affect.

The policy must always be to progress as much as is possible without rousing too great an opposition from any quarter, and I think it will be seen that the progress made during the last twenty-five years has, by the various annual increments, been perhaps more than could have been hoped for, and gives a promise for even more rapid advances in the future.

As an appendix to this Address I have given a brief epitome of the increases in students, in schools, in laboratories, and in grants which have taken place since 1861. If to the last be added the amount spent out of the whisky money an additional half million may be reckoned.

It will be seen that the progress made has been gradual but satisfactory, and that, if we showed some of the results graphically, weighted according to the circumstances of their date, and dared make an extrapolation curve of future results, we should have a complete justification for prophesying hopefully.

The question of the supply of science teachers has already been referred to. My remarks I should like to supplement by saying that in the greater number of schools teachers are to be found who have been trained at the Royal College of Science, and mostly at public expense—some through scholarships gained by competition and some through training selected teachers. The success of the movement for the introduction of science instruction in schools depended on

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the proper supply of teachers, and even now the demand for men possessing the highest teaching qualifications in science is greater than the supply. It may be said, I think, that our science teachers from the college have one special qualification, and that is, that besides the knowledge of science, practical and theoretical, that they have acquired, they have lived in an atmosphere of what is called research, and which might be called original investigation. Professors, assistants, and students alike are impregnated with it, and when the teacher so trained takes up his duties in his school he still retains the 'reek' of it. True instruction in science should, as I have before said, be practical, and practical instruction should certainly include original inquiry into matters old or new. The teacher who retains the 'reek' is the teacher who will prove most successful. It will thus be seen that the State had the task before it, not only of introducing instruction in science, but of training teachers to give such instruction. This problem is the same as now exists in Ireland, and the experience gained in England cannot but be of the greatest use to those at the head of Irish technical education.

Before concluding there is one subject that I must lightly touch upon, and that is the supply of teachers other than science teachers. The Education Act of 1870 gave the power to elementary schools to train pupil teachers, who in the process of time would become teachers, either by entering into a training college by means of a King's Scholarship or, less satisfactorily, by examination. In large towns the need of a proper training for pupil teachers has been felt, and gradually pupil teacher centres were established, principally by School Boards, where the training could be carried out more or less completely; but in the rural districts and smaller towns the pupil teacher has had to be more or less self-taught, and except in rare cases 'self-taught' means badly taught. The Training College authorities make no secret of the fact that one of the two years during which the training of the teacher is carried out has to be devoted more or less to instructing the pupils in subjects they ought to have been taught before they entered the college. Thus all the essential and special instruction which is given has to be practically shortened, and the teacher leaves the college with less training than he should have.

The new Education Act has put it in the power of the educational authorities to rectify the defects in the training of pupil teachers. It is much to be hoped that Councils will separately or in combination either form special centres for the training of all pupil teachers or else give scholarships (perhaps aided by the State) to them, to be held at some secondary school receiving the grant for science and recognised by the Board of Education as efficient. The latter plan is one which commends itself, as it ensures that the student shall associate with others who are not preparing for the same calling in life, and will prevent that narrowness of mind which is inevitable where years are spent in the one atmosphere of pedagogy. The non-residential training college, where the training of the teacher is carried on at some university college, is an attempt to give breadth of view to him, but if attempted in the earliest years of a teacher's career it will be even more successful. All teaching requires to be improved, and the first step to take in this direction is to educate the pupil teacher from his earliest day's appointment, for his influence in after years will not only be felt in that elementary, but will also penetrate into secondary, education. In regard to the additions which are required in elementary education, and which require the proper training of the pupil teacher, I must refer you to a report which will be presented to the Section. The task of training pupil teachers is one which requires the earnest and undivided thought of the new Education Committees.

In the earnest Address given by my predecessor in this Chair he brought forward the shortcomings of secondary education and of the requirements for a military career in a trenchant manner and with an ability which I cannot emulate. With much of what he said I agree heartily, but I cannot forget that, after all, the details of education are to some extent matters of opinion, though the main features are not. We must be content to see advances made in the directions on which the majority of men and women educational experts are agreed. Great strides have

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already been made in educating the public both in methods and subjects, but a good deal more remains to be done.

It may be expected, for instance, that the registration of teachers will lead to increased efficiency in secondary schools, and that the would-be teacher, fresh from college, will not get his training by practising on the unfortunate children he may be told off to teach. It may also be expected that such increased efficiency will have to be vouched for by the thorough inspection which is now made under the Board of Education Act, by the Board, by a university, or by some such recognised body. It again may be expected that parents will gradually waken up to the meaning of the teacher's register and the value of inspection, and that those schools will flourish best which can show that they too appreciate the advantages of each.

I have to crave pardon for having failed to give an Address which is in any way sensational. I have thought it better to review what has been done in the past within my own knowledge, and with this in my mind I cannot but prophesy that the future is more than hopeful, now that the public is beginning to be educated in education. It will demand, and its wants will be supplied.

APPENDIX.

Number of Schools of Science and their Grants.

Year	Higher-grade Schools	Endowed Secondary Schools	Technical Institutes	Total Schools	Total Grants
					£
1895	53	30	29	112	39,163
1898	69	50	49	168	98,849
1901	63	106	43	212	118,833
1903	50	119	57	226	Not yet known [1]

[1] In 1902 124,300*l.* was paid.

Number of Schools teaching Shortened Course of Science.

Year	No.
1902	127
1903	184

Number of Laboratories recognised.

Year	Chemistry	Metallurgy	Physics	Biology	Mechanics
1880	133	—	—	—	—
1900	669	37	219	17	4
1901	722	37	291	26	10
1902	758	39	320	34	14

Grants paid for Science Instruction.

Year	Amount	Year	Amount
	£		£
1860	709	1890	103,453
1870	20,118	1895	142,543
1875	42,474	1901	212,982
1880	40,229	1902	240,822
1885	63,364		

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The following Papers were read:—

1. *On School Curricula.*

i. *By* Professor MICHAEL E. SADLER, *M.A., LL.D.*

1. *Curriculum of Primary and Preparatory Schools.*

Under this head are included (*a*) public elementary schools the curriculum of which ends about fourteen; (*b*) schools which are preparatory to secondary schools (these again in turn are preceded by instruction given either in schools for little children or by governesses); and (*c*) kindergarten and preparatory schools attached to secondary schools.

Nature and Scope of Early Studies.—In this grade of education there is great advantage in educating boys and girls together. In many ways these early years are educationally the most critical years of a child's life. Great importance should be attached to the aptitude of the teachers, and to their sympathy with young children. Care should be taken to avoid (1) rigid separation of the subjects, and (2) on the other hand namby-pambiness. Children are not strengthened for the tasks of later years by being kept back too long from facing real difficulties. The point of junction between the kindergarten and the lower school needs more attention educationally than it has generally received.

In this stage of education special importance should be attached to training the powers of expression alike in the mother tongue, with the brush, with the fingers, and (through dancing and physical drill) with the body and limbs. The ideal course of education for little children is one which carefully combines *mousiké* and *gumnastiké*. Much can be done to lay a good foundation for the study of geometry. Stress may also be laid on the importance of the intelligent teaching of arithmetic. In the curriculum, at this stage, history-teaching best takes a biographical form, but different children show remarkably different aptitudes for historical studies. Emphasis should be laid on the need for good teaching of geography, and for the intelligent study of living things (particularly of plant life); on singing and physical exercises, and on well-organised and carefully supervised school-games. So far as it can be arranged, group-work is to be recommended, *e.g.* in connection with the teaching of history and literature, rough models can be made by a small class of children. Modelling, drawing, simple carpentry, painting, and other forms of expression through the hand are particularly valuable. Care should be taken to encourage children to ask questions instead of discouraging anything which interrupts a preconceived plan of lesson. A good school combines discipline with the encouragement of individuality.

Effect of Scholarship Examinations on the Curricula of Preparatory Schools.—The powers of different children vary so greatly in degree and in rapidity of development that it is very difficult to mention a point up to which a common course of instruction should be carried. There is reason to regret the numbing effect of our public-school scholarship and entrance examinations on the education of little boys. The grip of the classical tradition is nowhere more mischievous than in the control of the education of little boys up to the age of twelve. In our preparatory schools (admirable as they are in tone and in their individual care of the character of the boys), we fail properly to teach them the use of their mother tongue; we fail as regards the teaching of history and the creation of a love for literature; we fail to make proper use of geography as a school subject; we have far too little manual training and drawing; and there is little leisure for the intelligent study of nature. And the root of all the trouble is the artificially high standard of attainment in Latin and Greek which is required at the public schools at their entrance examinations.

Improvement desirable in Classical Teaching.—In order to facilitate the transference of promising pupils from the elementary schools to the secondary schools at twelve years of age, much is to be said for the 'reformed curricula' which are now being adopted in an increasing number of German classical schools.

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2. *Curriculum of various Types of Secondary Schools.*

A protest should be made against the assumption that boys and girls of secondary school age ought to go through the same course of studies. It may be doubted whether it is at all wise to give, in ordinary cases, to girls between the age of twelve and sixteen as heavy a burden of work as can be borne by many boys of the same age, though even among boys there are great differences of strength and in the rate of physical and mental development.

There are three types of secondary education which seem to call for separate treatment. By separate treatment is meant the assignment of a special curriculum.

The three types of curricula would be as follows:—

(*a*) *Engineering and other professions depending on Applied Science.*—A secondary school leading up to the engineering professions (mechanical, electrical, civil, and mining) and to other callings connected with applied science. The aim of such a curriculum should be to equip a boy at sixteen with the following attainments: command over his mother tongue, interest in history and good literature, sound knowledge of geography, thorough grounding in mathematics, skill in speaking and writing one modern foreign language, fair acquaintance with the requirements of physical science, and skill in using the pencil and brush.

(*b*) *Commercial Professions.*—For commercial professions, the time assigned to mathematics and to laboratory work in science might be somewhat reduced in order to make room for a second modern language. As another form of this curriculum, many experienced men of business would recommend a combination of Latin and one modern language.

(*c*) *Literary Professions.*—For the more literary professions, a curriculum providing for instruction in French, Latin, and then Greek or German (in the order stated), would naturally follow to some extent the lines of the Frankfort curriculum.

3. *Desirable Reforms.*

(*a*) We ought to have in our English schools far better teaching of the mother tongue and more skilful training in expression and composition in English. In this regard we have much to learn from the French schools, and a good deal from the German. But of the two the French methods seem to me much the more artistic. The German methods are rather prosy for English children.

(*b*) In the early years' secondary education for boys we are suffering from premature Latin and Greek. The scholarship system at the public schools is fast becoming an educational curse.

(*c*) Far more prominence should be given throughout our primary and secondary education to manual and practical work of all kinds.

(*d*) Much of our education is sterilised by cramming up for examinations.

(*e*) Though history (except in its biographical forms) is by no means an appropriate subject for immature minds, much more can be done to stimulate historical interest by means of the better teaching of history in our schools and by giving the pupils a wider outlook over the development of nations upon the earth.

(*f*) Much more should be done to introduce improved methods of geographical teaching into schools.

(*g*) We are sadly behindhand in our standards and methods of modern-language teaching. There is likely to be a shortage of well-educated young English teachers competent, by residence and training abroad, to teach French and German on the best new methods, while at the same time able to link those subjects to the other parts of the school curricula.

(*h*) Let us avoid over-teaching English pupils. We do not want to produce a passive generation. It is far better that our boys and girls should learn a little thoroughly than get a smattering of a number of subjects. When they leave school, they ought only to be beginning to learn.

(*i*) It is to be desired that every school should state its intellectual aim; publish (according to some approved form) a statistical summary of the hours and work

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given weekly in each form to each subject in the curriculum; and issue an outline of its course (or courses) of study, showing the standard which it proposes to reach at each stage in each class.

(*j*) Behind all consideration of curricula, there must lie an ideal of character and of the kind of intellectual power which we desire the rising generation of English men and women to reach.

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ii. *By* Professor J. Adams, *M.A.*, *B.Sc.*

1. *Groups of Essential Subjects.*

The subjects that all children should study in common fall naturally into four groups. (*a*) The three R's, as the necessary preliminary to all formal study; (*b*) English composition and drawing as means of expression; (*c*) Drill, some form of manual work, singing, and the rudimentary laws of health; (*d*) Nature study, geography, and picturesque history and biography.

2. *Literary and Practical Subjects.*

While all training should include both theoretical and practical instruction, the nature of the subjects to be taught and the amount of time to be devoted to each must vary with the stage of advancement of the pupil. In a well-equipped school with a good staff and small classes, the greater part of the formal teaching of the three R's could cease at the age of ten, though occasional formal lessons, particularly in arithmetic, should be provided up to the age of twelve. With regard to the other subjects of common study there is no need that they should ever be dropped, though the form in which they are carried on and the material upon which the mind is exercised may be changed. Geography and history, for example, may altogether change their character as school subjects, and yet the lessons of the earlier stage may retain their value. The subjects thus do not merely change, they develop. Nature study may be given up entirely in favour of systematic botany or physiology or chemistry, but it leaves behind it its mass of knowledge with the corresponding bias towards scientific method.

The literary part of the curriculum should be made as general as possible, that is, as free as may be from specific applications to professional purposes. English composition need not by any means become tainted in school with the peculiar terms of the counting-house. The vocabulary and idiom of the different professions can be very readily picked up by an intelligent pupil who knows good English. The reading of what is known as literature is the best possible preparation for all sorts of professions that require the power of expression.

French and German should be treated on the same principle. It is easy to make fun of the boy preparing for the counting-house by puzzling his way through a German passage dealing with goslings and golden hair. But there is, after all, only one German language, and it is better that it should be approached on the human side rather than the commercial. The first essential is that the pupil should leave school with the power of reading easily and intelligently the foreign languages he has studied. To attain this end he must have read widely during his course. Nothing can make up for the lack of wide reading. Composition in the foreign language is an admirable culture training, leading to the corresponding practical advantage of facility in writing. The commercial pupil must acquire the power of composing in the foreign language, but this is less essential in the case of the scientific pupil, though of course highly desirable.

The same thing is true about mathematics. In order that each class of student should be able to make the proper application to his own subject, all the pupils must study mathematics in general. The domestic, scientific, and commercial professions all demand a knowledge of mathematics in some form or other. In the case of the literary professions it is not essential that mathematics should be studied in any great detail. Some geometry and algebra treated in the broadest

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way is enough to give the literary pupil the mathematical point of view, but beyond this it is not necessary to urge him to study unless he has a bent that way.

Of the practical subjects, probably drawing is of the most general application. As a means of expression it ought to be studied by all classes of pupils.

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iii. *By* T. E. PAGE, *M.A.*

1. *The Scope of Education.*

Education may deal with (1) moral and religious; (2) intellectual; (3) physical; and (4) technical training.

The first of these divisions may here be put aside. The spirit of morality and religion is, like a pure and invigorating atmosphere, essential to healthy educational life, but it evades inclusion in a curriculum. In so far as it can become a part of schoolwork, moral and religious teaching passes into division 2, being closely connected with 'Literary Instruction.' Time devoted to this subject must be devoted to a real examination of what the Bible is and says, not to the eccentricities of Hellenistic Greek or trivial lists of obscure Israelite kings.

As to division 3 it may safely be said that 'physical training' is not a necessary part of a school curriculum. Whatever its importance in primary schools, in secondary schools, and especially the higher ones, such training is fully, perhaps too fully, secured by a great variety of games which, in addition to their physical effect, help to develop nerve, readiness, resource, and other qualities in a way which no formal course of drill or gymnastics can equal.

With regard to 'manual training,' doubtless the payment of manual skill is steadily increasing, while that of the lower forms of 'headwork' is steadily decreasing; a good mechanic is more secure of good pay than an average clerk or a moderate schoolmaster.

Technical training (4) has nothing to do with education proper. In special cases it may be advisable to admit it, but it has no place in any *general* curriculum.

2. *The Three Necessary Elements of Education.*

If the right meaning has been now given to 'education,' and the field of its exercise been rightly limited, it follows that it consists in such *intellectual* training as will produce the best general capacity, and such training falls into certain necessary divisions. Possibly the cultivation of memory deserves to be treated as a separate division of education—and the subject certainly deserves special study—but, as its use and exercise is developed by all teaching, we may perhaps eliminate it in tracing the necessary divisions of any course of study, and say that there are three, and three only—Literature, Mathematics, and Science.

3. *All Three Elements must be Combined.*

It is on the proper combination of these three that the success of any curriculum must depend. But there must be *combination*, for assuredly education at its best is the equal and harmonious development of all the faculties, not an effort to force abnormal growth in any one, just as physical training is a training of the whole body, and not of any part, though of course it often 'pays' to develop extraordinary excellence in a single direction. The policy of the great universities, which by refusing all reward to general excellence in several pursuits, forces most boys of promise, often two or three years before they leave school, into one single and often very narrow path of study, is to be deplored. Nor is it a less deplorable result of this policy that the men they send out to become teachers are almost always men of one pursuit.

4. *The Position of Science.*

The curriculum in most secondary schools was until recently (1) Literary and (2) Mathematical, such subjects as history and geography (the latter with far too large an addition of mere map-making) being somehow tacked on to the literary

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part of the work. Lately, however, science, long treated in schools as a sort of Cinderella, has shown a tendency to play the part of an imperious queen. About the value, on the other hand, of mathematics, there can be no doubt; experience has demonstrated their power to strengthen and invigorate the mind; *μηδεὶς ἀγεωμέτρητος εἰσίτω* is still written large over the door of knowledge. For others, too, less capable of abstract thought, study of the laws of language and the effort fully to understand and appreciate the great thoughts of great men, is a discipline that has stood the test of time. But the value of the study, say, of botany, of electricity, or of geology, as a means of training is, as yet, to say the least, 'not proven.' Primarily, most of the sciences rest on the basis of an enormous accumulation of observed facts, and it is *after* the facts have been accumulated that reason, intelligence, and imagination begin to find in them a field for exercise. What is to be deprecated is that the teaching of science should assume too large a place in education, owing to a vague opinion that, because science is of the highest practical value, it therefore affords the best training for practical life.

5. *Curriculum affected by Leaving Ages of Pupils.*

What the exact arrangement of literary, mathematical, and scientific training in a curriculum should be it is impossible to state precisely, for it is absurd to suppose that one curriculum will suit all varieties of schools, from small local grammar schools to the large public ones. Obviously the training suitable for boys who stay at school until eighteen or nineteen, and then proceed to some university to spend three or four years more in preparation for some learned profession, must differ from that of boys who have to begin actual work at sixteen, and each school must modify its curriculum to meet its own special needs.

But in every curriculum what is vital is that its main plan and purpose be sound, that it help to form a complete man, capable of using all his faculties of speech, reason, and observation to best advantage, and, above all, that it impress on his mind a deep conviction that what he has learned is as nothing to what he has yet to learn and must go on learning through life.

6. *Influence of Examinations and Teachers.*

Examinations many and manifold, complex and confusing, are at present the real masters of education. They control the whole course of study, and it is absolutely idle to establish any systematic curriculum until sense, system, and simplicity are in some measure introduced into examinations. Further, the best curriculum is worthless without good teachers.

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iv. *By* G. F. DANIELL, *B.Sc.*

In the spring of 1902 Canon Lyttelton suggested that it would be both interesting and valuable to obtain and collate the views of teachers on the subjects essential to an ideal curriculum, and on the order in which they should be taken (*e.g.* should Latin be begun before French, or *vice versa*?). The idea developed, and during the autumn of 1902 and the spring of 1903 a series of meetings was held, altogether about thirty in number, and reports have been received at the Teachers' Guild headquarters.

The following is a summary of the conclusions arrived at as the result of this inquiry:—

1. *Classification of Results.*

The returns with reference to secondary (including preparatory) schools may be classified as follows:—

Part I. contains the conclusions with regard to which there is practical agreement.

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Part II. suggests topics especially suited for debate.

Part III. contains suggestions, some of which may prove to be of considerable value.

2. *Essential Subjects.*

Part I.—From reports kindly furnished by officers of eleven branches and six London sections, there appears to be practical unanimity as to the following:—

The curriculum should include: (1) Religious instruction; (2) English (attention being given to oral as well as to written composition); (3) French; (4) Latin (two London Sections and the Guernsey branch made this optional); (5) History; (6) Geography; (7) Arithmetic; (8) Algebra, begun informally as generalised arithmetic; (9) Geometry, formal study should be preceded by lessons in form and measurement; (10) Science, which should begin with object lessons or nature study, and become formal at about the age of thirteen; (11) Handwork, including sewing for girls; (12) Drawing; (13) Physical exercises (some include swimming); (14) Class singing. It was further agreed (1) That French should be begun before Latin; (2) The ordinary curriculum for boys and girls leaving school at sixteen and seventeen should not include Greek; (3) Specialisation should not be allowed until the general development of the pupil is secured, usually not before sixteen.

3. *Undecided Questions.*

Part II.—There was a conflict of opinion as to the following: (1) Whether German should be compulsory; the majority made this optional. (2) Whether English Grammar should be treated as a separate subject; majority affirmative. (3) Whether language and literature should be taught separately (*i.e.* separated on the time-table); majority affirmative. (4) Whether separate lessons on civics should be given, or whether this should be taught through history; majority for the latter. (5) What should be the age for beginning laboratory work; thirteen was the favourite age. (6) Whether the use of Euclid's Elements should be retained; majority for retention. (7) Whether instrumental music and shorthand should form part of the ordinary curriculum.

4. *Suggestive Opinions.*

Part III.—The following opinions were expressed by one or more branches or sections: (1) That no subject should be included in the curriculum to which a definite minimum of time could not be allotted; (2) That each subject included should be carried through to the fullest extent possible in the school; (3) That dancing and hygiene should be taught in schools; (4) That domestic science should be taught in girls' schools, including household book-keeping; (5) That handwork should not take the form of Sloyd; (6) That boys should be taught shooting; (7) That scholars leaving at sixteen or seventeen years of age for a scientific career may substitute extra practical science for Latin; (8) That history should be correlated with literature and geography with elementary archæology; (9) That the history and appreciation of art should be taught, to include styles of architecture, sculpture, painting, and the lives of great artists; (10) That botany is the most convenient subject for the study of natural history; objects should be compared, drawn, and described; (11) That laboratory work should be begun whenever science work is begun.

5. *Practical Importance of Exchange of Views on Curricula.*

Any attempt to formulate a rigid Code is undesirable, and consequently discussions on curricula should be periodically promoted, in order that: (1) Interest in such problems may be maintained, and individual experiences and methods be made common property; (2) Teachers isolated by distance or otherwise may be kept in touch with recent improvements; (3) Teachers, particularly specialists,

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may acquire knowledge of, and sympathy with, the work of colleagues in subjects other than those in which they are specially occupied; (4) Specialists may receive useful criticisms from colleagues who may be regarded with reference to their special subject as 'intelligent outsiders'; (5) The claims of new subjects to admission to the curriculum may be demonstrated to the non-specialist; (6) Suggestions may be afforded as to what subjects can be omitted from an overcrowded time-table in order to avert the peril of 'shallowness.'

FRIDAY, SEPTEMBER 11.

The following Papers were read:—

1. *On Curricula of Girls' Schools.*

i. *By* Miss S. A. BURSTALL, *B.A.*

1. *Introduction.*

Broad curriculum advocated rather than a narrow specialised curriculum. Reasons:—

(*a*) Actual acquisition of knowledge.
(*b*) Training of the mind; different subjects train different faculties.
(*c*) Development of the child; subjects should be suited to the child's age.

The various aspects of the subject may be considered under the following heads: (1) General character of curriculum; (2) Types of schools; (3) Commercial professions; (4) Engineering and applied science professions; (5) Domestic professions; (6) Literary professions; (7) Subjects for schools of different types.

I. Age 12–13	II. 13–14	III. 14–15	IV. 15–16	V. 16–17.	VI. 17–18.
HUMANITIES.					
History, Geography, Literature, English, &c. } 8	Same as I. . 8	Ancient History, English History, Geography, Literature, &c. } 8	General European and English History, Geography, Literature, &c. (4 periods compulsory, 4 optional.)	English Literature and History 4 Mathematics, Algebra, and Geometry . . . . 4 One foreign language . . . . 4 (All compulsory.)	
LANGUAGES.					
French, German, or Latin } 8	Same as I. . 8	Same as I. . . . 8	Latin . . . . . 4 German . . . . 4 French . . . . 3 Greek . . . . . 4 (Only one compulsory.)	Specialisation in Languages.	
SCIENCE.					
Arithmetic, Elementary Geometry, Elementary Physics } 8	Arithmetic, Geometry & Algebra, Nature Study } 8	Mathematics . . 8 Physics . . . . 8 Nature Study (alternate with some English Study) . . . 2	Mathematics . . 5 (Compulsory.) Physics, Chemistry, Botany, &c. (One compulsory, rest optional).	Specialisation in Science and Mathematics.	

The figures denote minimum number of lessons per week. Physical training and one branch of handwork compulsory throughout. English composition included in the Humanities section.

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2. *Conclusion.*

Limitation of material to be learnt essential; masses of detail not necessary for thoroughness, *e.g.* anomalous forms in Latin grammar, the less important metals in chemistry, details of battles and campaigns in history.

An *outline* course, with typical examples accurately known and properly understood, does not mean superficiality.

Organisation.—Different courses: Classical, scientific, commercial, &c., overlapping in some subjects of general education, may be given in different parts of the same school. This plan works very well in large schools (*cf.* America). Or a particular school may give one or two courses only; *e.g.* a small school may refuse to specialise in classics or in science, or any school may fix a rigid curriculum and appeal to one type of pupil only, like the American manual training high school.

Local differences and local conditions and needs make variety essential. Freedom vital in education.

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ii. *By* Professor H. E. Armstrong, *Ph.D., LL.D., F.R.S.*

1. *The Basis of a Rational Curriculum.*

The education of the future must be practical and individual, such as will directly fit boys and girls for their work in the world, such as will appeal to their sense of intelligence, such that they will value it instead of shirking it whenever possible.

Literary methods must give place to practical methods; workshop methods must take the place of didactic desk methods. The schools of the future must be in charge of broad-minded, practical men and women, trained scientifically and in the world as well as in academic grooves. Consequently, the training of teachers, examiners, and inspectors must be conducted on more rational and practical principles than heretofore, in order that a race may arise capable of coping with a rational, practical curriculum.

2. *Essential Subjects for all Pupils.*

The subjects which all children should at first study in common must be such as to develop *all* their faculties.

Every child should be taught to read well and to like and use books—a very large amount of time should be devoted to reading—the habit of reading out loud should be carefully cultivated. At whatever age children leave school, they should be well read for that age and know how to turn to books for information.

The teaching of our own language, of history, and to some extent of geography, should be largely incidental to reading. Mere lesson-learning should be abolished, both in and out of school. Children should be encouraged, indeed taught, to talk rationally, and much about their work and of things around them.

At most half the school time should be devoted to literary studies—to studies conducted by literary methods. *At least half* should be given to practical studies—to experimental and manual work.

The prime object in view in experimental work should be the formation of character—the cultivation of some measure of thought power and of a seeing eye, not the acquisition of knowledge.

Literary training might be given largely in connection with such work to supplement that given through reading; there would be something real to write about, something seen, felt, or discovered, so that the habit of writing about real things would gradually be acquired.

The teaching of mathematics and of drawing should also be made incidental to the experimental work.

With regard to manual training, something far more real than what is now

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done must be introduced into schools. This class of work should be made as attractive as any game; in fact, it should be organised on a similar footing, directly in co-operation with the scholars. It is of the utmost consequence that various branches of manual training should receive adequate and serious treatment in all schools.

3. *Interest and Individuality.*

In the boarding school of the future there should be little or no evening lesson-learning of the conventional type; the time will be far more usefully spent and in a more healthy manner in experimental and manual work..

In the future, besides manual training, general physical training must receive a due share of attention. When the formalities of classics no longer fill the mind, the example set in classic times may meet with some recognition: some effort will be made to embody Greek ideals in our scholastic practice.

The higher should differ from the preparatory school mainly in the extent to which proclivities which become manifest during the preparatory course are given scope for development, in the increasing difficulty of the tasks set, and in the increasing demand for results.

4. *General and Professional Education.*

Undue specialisation may have an effect the very opposite to that which it is argued makes specialisation desirable. In all careers the preliminary qualification of most worth is general intelligence.

Arguments such as these favour the conclusion that in schools generally both literary and practical studies should at all times receive adequate treatment, and that specialisation should as far as possible be avoided. The differences that should be allowed to arise between different types of school should be differences in the character of the work done within either of the two main branches—in the character of the reading or in the choice of subject-matter for the experimental studies.

5. *The Domestic Profession.*

It is a very serious outlook for the country that the higher education of women is almost entirely in the hands of those who have been trained in schools where academic views prevail almost exclusively. The very fact that women have only asked that they should be allowed to do as men do, to have what men have, is proof that they have failed to understand the position they hold.

6. *Aims of Scientific Instruction.*

It is essential that whatever be done should be done thoroughly: the object in view is to teach method; it is not primarily a question of results. The requirements of examining bodies of the present irrational type must be resolutely set aside.

The various branches of science are not of equivalent value as educational instruments. Physics and chemistry are the foundations, as it were, of scientific belief; they underlie all natural phenomena, all vital changes. But although it is necessary, before attempting in any way to consider the nature of the processes which attend life, to understand the fundamental principles of physics and chemistry, there is no reason why the biological sciences should not receive attention at a very early stage. In physics and chemistry experiments can be made in a way and with a degree of completeness which is impossible in the case of the biological sciences; the latter, however, afford unrivalled opportunity of cultivating observational power. But in future the object of schools will be to give their scholars a broad outlook over nature; to create interest in all that goes on around them.

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2. *On School Curricula with Special Reference to Commercial Education.*

i. *By* J. L. PATON, *M.A.*

1. *Special Commercial Schools Undesirable.*

Whether it be medicine, law, the Church, or commerce, or even schoolmastering, it is hardly fair to earmark a boy at the age of ten, or perhaps younger, for this or that particular walk in life. Up till the age of fifteen every school ought to be what Ruskin calls a 'discovering school,' finding out for what a boy is best fitted. Specialised classes there must be, every secondary school must bifurcate towards the top, but such classes should be put as late as possible, not as early.

2. *Not Manual Dexterity but Mental Discipline.*

By 'education for commercial professions' is meant an education not only unmistakably secondary, but super-secondary; that is, based on a sound general education of a secondary grade. Up to the age of fifteen or sixteen—that is, up to the standard which is represented, at the very lowest, by Honours in the Junior Oxford and Cambridge Locals—the thing 'commercial education' should not be so much as named.

3. *Character and Scope of Foundation Studies.*

The mode or the method is the most important thing in these earlier stages. The mother tongue is not taught as well as it should be. Two things need to be insisted on: (1) Clear articulation, with some differentiation of the various vowel sounds, too apt to be lost in an indiscriminate *er*-sound; (2) The proper formation and management of sentences.

Again, in modern languages we must discard the heavy classical method of grammar and exercise. Sound must come first. Speech cannot be articulated till the vocal organs have learned to form the component sounds.

We will suppose now that our boy has passed through this stage, that he has a fair equipment in English, in one modern language at any rate, in arithmetic, geometry, and algebra, in the history of his country, and the geography of the chief countries of the world; also some elementary and practical knowledge of drawing, mensuration, physics, and, perhaps, chemistry; if Latin too, so much the better. We pass now to the commercial department, the specific preparation for commerce. We assume that, 'in whatever matters it is our duty to act, those matters it is also our duty to study.' How do we set about it?

4. *Specific Preparation for Commerce.*

The first subject in which specialisation is possible is *Arithmetic*. This must begin, if it has not begun already, with thorough drill in the metric system and the monetary systems, the weights and measures of other countries with which England trades. The next thing is to learn the decimalisation of English money, and therewith all manner of rapid and abridged processes of calculation. Closely in touch with arithmetic, and taught by the same master, must go commercial knowledge—questions of freight and navigation, insurance and tariffs, companies, shares, computation of annuities, mortgage loans, the elements of banking and bills of exchange; how debts incurred in London may be extinguished in Hamburg, the rate of exchange, and difference between gold and silver standards of currency. Systematic instruction in these things will involve the working out of practical problems by arithmetic at every step, and care must be taken that there is plenty of mental computation. The terms used must be made real as much as possible by reference to actual reports of commerce and current newspapers, also by visits to the Docks, to the Clearing House, to the Mint, to large commercial and industrial houses. Clearly this is not a matter of text-book

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merely; no text-book, however good, will suffice in itself. The teacher must have actual experience of business.

The *French* and *German* must also begin to take a special bias. The language itself must be used as the vehicle of teaching; a complete series of letters should from time to time be written completing a transaction between an English and a foreign firm; and the composition should be what is called 'free composition' rather than literary translation.

In *History* the first year should be given to the history of the world, and then in the second year work over the same ground again, studying it from the special economic point of view.

Geography must also now become a world-subject, and no longer an affair of separate countries. It will begin with examining the world-distributions of temperature, pressure, wind, and rainfall, with the causes that produce them; the sea currents as they affect climate. This opens up the question of economic vegetation and the distribution of animals. Next come minerals and coal. And then, as the resultant of all these circumstances, comes the population. For all this work special maps are required; the Geographical Association provides some excellent slides. After this comes regional geography of the geographical area. The region is first defined by emphasising the relief of the area under treatment with rough accounts of structure, climate, and vegetation, and population as before, with the special reasons which have caused the growth of certain towns. Then comes the question of routes within the area, as based on relief and water system, and last of all trade routes and trade relationships with other countries, transit, cable routes, and all communications.

Economics should not come till the second year, and they should be commonsense and practical thinking about the most obvious phenomena of our social life.

A high mathematical standard should be insisted upon for entry to the commercial department. The arithmetic cannot be done without it. Also, a boy should have, before going into business, some knowledge of the chemistry of common life and merchantable objects, of the mechanics and the main motor powers used in manufacture.

The *English* should be as little as possible formal or philological. The composition should arise out of the teaching, but it will not be by any means confined to the English class. The history, geography, and economics will all involve essay writing. The composition should not be all written, every commercial course should include practice in speaking, but this can hardly be a class subject, it should find its free and spontaneous scope in the school debating society.

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ii. *By* W. C. Fletcher, *M.A.*

It should not be forgotten that in discussion of curricula—still more, of course, in their enforcement—conclusions must not be sharply defined, and that behind any curriculum lies a much more important matter—the personality of the teacher.

1. *Knowledge for its own Sake.*

Utility is no guide. Not that utility is objectionable as extremists have urged, but that it is unattainable. Of no conceivable subject in a school curriculum other than reading, writing, and the bare elements of arithmetic, can it truly be asserted that it will be 'useful' to all, or even to any considerable fraction of the whole number of children.

2. *Faculties to be Developed.*

After the bare elements, the absence of which distinguishes the legal 'illiterate' from the rest of the community, the essentials to be secured, if possible, are: (1) the power of accurately following thought properly expressed; (2) the power of thinking accurately oneself; and (3)—which can perhaps hardly be separated

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from (2)—the power of accurately expressing one's own thought. This is what we mean by mind training. Education does—or should—include also the discipline and development of the emotions and judgment, æsthetic and moral, as well as merely intellectual.

These two sides of education—disciplinary and æsthetic they may perhaps be called for shortness—constantly overlap, but they must both be kept in mind if a curriculum at all tolerable is to be secured.

3. *Uniformity of Curriculum desirable in Lower and Middle Forms.*

Whatever differences exist between school and school, it is desirable that (in the lower and middle forms at least) all should follow the same curriculum.

A common curriculum is a powerful factor in that community of interest and feeling which should be maintained as far as possible, and whose maintenance is especially difficult under the conditions of city school life. No considerations of utility, which at best are uncertain and probably delusive, seem to me sufficient to outweigh this vital consideration. This does not, of course, apply to the top form of a school, where a considerable amount of variety and specialisation can, and should, be permitted.

4. *Place of Manual Work.*

Manual work—*i.e.* work in clay, wood, metal, &c.—does sometimes give the needed chance of interest and success to a boy who in ordinary school subjects is a 'hopeless duffer.' This alone would justify its inclusion in one form or another in all curricula, but it does not need this justification. It gives valuable assistance in making arithmetic and drawing more real and intelligible; some forms of it demonstrate as nothing else does the difference between accurate and inaccurate work, hence have a considerable moral value; it interests most boys, so making them more favourably disposed to school work as a whole, no small advantage.

5. *The Discipline of Scientific Studies.*

Natural science does not seem to come under the head of practical instruction in at all the same sense as manual work.

It is true that actual handling and examination of things, actual construction and measurement, is an essential part of it, but it is not the whole, nor, as every teacher knows, the most difficult part. Exact statement of what is observed, co-ordination of new experience with old, the disentanglement of the essential from the accidental, the building up by reflection and discussion of a coherent body of truth, demand clearness of thought and, what can seldom if ever be divorced from that, clearness of expression. These requirements make natural science properly handled an admirable discipline, but it is a discipline which has quite as much in common with the discipline of mathematics and literary subjects as with that of manual work. But further it should be added that the influence of natural science teaching has reacted most favourably on the older subjects. Anyone with the scientific habit of mind will approach the teaching of, say, Latin in a way very different from the traditional method. He will lay much more stress on observation and reason and inquiry than on dogma.

6. *The General Curriculum.*

Manual instruction, in one shape or other, should be carried on in the lower and middle forms, natural science in the middle and upper, not excluding, of course, simple observational science, even among the youngest boys if conditions permit, and literary subjects throughout.

As to the latter, they will include—besides mathematics—history, geography, and literature with languages. If adequate attention is to be given to other essentials, not more than two languages should be attempted except by boys in the upper forms specialising in this direction. Up to about the age of sixteen

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boys should be kept together; if by this time they have a competent elementary knowledge of the subjects indicated, they may with advantage if they stay longer at school be allowed to concentrate on subjects which more especially interest them, whether for professional or purely scientific purposes. Earlier specialisation has no advantages.

MONDAY, SEPTEMBER 14.

The following Discussion took place and Reports were read:—

1. *Discussion on the Teaching of Geography.*
Opened by H. J. MACKINDER, *M.A.*—See p. 722.

2. *Report on the Teaching of Botany.*—See Reports, p. 420.

3. *Report on the Conditions of Health essential to the carrying on of the Work of Instruction in Schools.*—See Reports, p. 455.

TUESDAY, SEPTEMBER 15.

The following Reports were read:—

1. *Report on the Influence of Examinations.*—See Reports, p. 434.

2. *Report on the Teaching of Science in Elementary Schools.*
See Reports, p. 429.

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Publications on sale at the Office of the Association.

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Second Report on the Development of Graphic Methods in Mechanical Science, 1892, 1*s*.

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The Action of Magnetism on Light, by J. Larmor, F.R.S., 1893, 1*s*.

Table of Electro-chemical Properties of Aqueous Solutions, compiled by Rev. T. C. Fitzpatrick, 1893, 1*s*. 6*d*.

Report on the Present State of our Knowledge of Thermodynamics, Part II., by G. H. Bryan, with an Appendix by Prof. L. Boltzmann, 1894, 1*s*.

Report on Planimeters, by Prof. O. Henrici, F.R.S., 1894, 1*s*.

Discussion on Agriculture and Science, Ipswich, 1895, 3*d*.

Reports on the North-Western Tribes of Canada, 1*s*. or 1*s*. 6*d*. each.

Fourth Report on the Erosion of the Sea Coast, 1895, 9*d*.

Second Report on a Gauge for Small Screws, 1884, reprinted 1895, 6*d*.

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Report on Proposed Modification of the Thread of the B.A. Screw, 1900, 6*d*.; Report 1901, 6*d*.

Digest of Observations on the Migration of Birds made at Lighthouses, by W. Eagle Clarke, 1896, 6*d*.

Report on the Migratory Habits of the Song-thrush and the White Wagtail, by W. Eagle Clarke, 1900, 6*d*.

Report on the Migratory Habits of the Skylark and the Swallow, by W. Eagle Clarke, 1901, 6*d*.

Report on the Migratory Habits of the Fieldfare and the Lapwing, by W. Eagle Clarke, 1902, 6*d*.

Report on Tables of the Bessel Functions, 1896, 1*s*.

Report on the Comparison of Magnetic Instruments, 1896, 4*d*.

Report on the Position of Geography in the Educational System of the Country, 1897, 6*d*.

Report on Seismology, 1898, 1*s*. 6*d*.; 1899, 1*s*.; 1900, 1*s*. 6*d*.; 1901, 1*s*.; 1902, 1*s*.

Report on the Bibliography of Spectroscopy in continuation of 1894 Report, 1898, 1*s*. 6*d*.; 1901, 1*s*. 6*d*.

Report on Wave-lengths, 1899, 1*s*.; with Index to Tables from 1884 to 1900, 1*s*.; 1901, 1*s*.

Tables of F (r, ν) and H (r, ν) Functions, 1899, 1*s*.

The Problem of the Three Bodies, by E. T. Whittaker, 1899, 1*s*.

Report on the Ethnological Survey of Canada, 1899, 1*s*. 6*d*.; 1900, 1*s*. 6*d*.; 1902; 1*s*.

The Chemical Compounds contained in Alloys, Report by F. H. Neville, F.R.S., 1900, 1*s*.

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The Constitution of Camphor, by A. Lapworth, D.Sc., 1900, 1*s*.

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Note sur l'Unité de Pression, par le Dr. C. E. Guillaume, 1901, 3*d*.

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Report on the Resistance of Road Vehicles to Traction, 1901, 3*d*. ; 1902, 1*s*.

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The President's Address, and Sectional Addresses, for 1889, 1892, 1893, 1895, 1896, 1897, 1899, 1900, 1901, 1902, 1903, each 1*s*.

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FOR

THE ADVANCEMENT OF SCIENCE.

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OF

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Corrected to January 1, 1904.

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1903.

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‡ indicates Subscribers not entitled to the Annual Report.
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Names of Members whose addresses are incomplete or not known are in *italics*.

Notice of changes of residence should be sent to the Assistant General Secretary, Burlington House, W.

Year of Election.

1887. *ABBE, Professor CLEVELAND. Weather Bureau, Department of Agriculture, Washington, U.S.A.
1897. ‡Abbott, A. H. Brockville, Ontario, Canada.
1898. §Abbott, George, M.R.C.S., F.G.S. 33 Upper Grosvenor-road, Tunbridge Wells.
1881. *Abbott, R. T. G. Whitley House, Malton.
1887. ‡Abbott, T. C. Eastleigh, Queen's-road, Bowdon, Cheshire.
1902. ‡ABERCORN, the Duke of, K.G. Barons Court, Ireland.
1885. *ABERDEEN, The Right Hon. the Earl of, G.C.M.G., LL.D. Haddo House, Aberdeen.
1885. ‡Aberdeen, The Countess of. Haddo House, Aberdeen.
1885. ‡Abernethy, James W. 2 Rubislaw-place, Aberdeen.
1873. *ABNEY, Captain Sir W. DE W., K.C.B., D.C.L., F.R.S., F.R.A.S. (Pres. A, 1889; Pres. L, 1903; Council, 1884–89, 1902–). Rathmore Lodge, Bolton-gardens South, Earl's Court, S.W.
1886. ‡Abraham, Harry. 147 High-street, Southampton.
1884. ‡Acheson, George. Collegiate Institute, Toronto, Canada.
1873. ‡Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1900. §Ackroyd, William. Borough Laboratory, Crossley-street, Halifax.

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1882. *Acland, Alfred Dyke. 38 Pont-street, Chelsea, S.W.
1869. †Acland, Sir C. T. Dyke, Bart., M.A. Killerton, Exeter.
1877. *Acland, Captain Francis E. Dyke, R.A. Woodmansterne Rectory, Banstead, Surrey.
1873. *Acland, Rev. H. D., M.A. Lamorva, Falmouth.
1894. *Acland, Henry Dyke, F.G.S. The Old Bank, Great Malvern.
1877. *Acland, Theodore Dyke, M.D. 19 Bryanston-square, W.
1898. †Acworth, W. M. 47 St. George's-square, S.W.
1901. §Adam, J. Miller. 15 Walmer-crescent, Glasgow.
1887. †Adami, J. G., M.A., M.D., Professor of Pathology in McGill University, Montreal, Canada.
1892. †Adams, David. Rockville, North Queensferry.
1884. †Adams, Frank Donovan. Geological Survey, Ottawa, Canada.
1901. †Adams, John, M.A. 12 Holyrood-crescent, Glasgow.
1871. †Adams, John R. 2 Nutley-terrace, Hampstead, N.W.
1869. *Adams, William Grylls, M.A., D.Sc., F.R.S., F.G.S., F.C.P.S. (Pres. A, 1880; Council 1878–85), Professor of Natural Philosophy and Astronomy in King's College, London. 43 Campden Hill-square, W.
1901. †Adamson, P. 11 Fairlie Park-drive, Glasgow.
1896. †Adamson, W. Sunnyside House, Prince's Park, Liverpool.
1898. §Addison, William L. T. Byng Inlet, Ontario, Canada.
1890. †Addyman, James Wilson, B.A. Belmont, Starbeck, Harrogate.
1890. †Adeney, W. E., D.Sc., F.C.S. Royal University of Ireland, Earlsfort-terrace, Dublin.
1899. §Adie, R. H., M.A., B.Sc. 136 Huntingdon-road, Cambridge.
1883. †Adshead, Samuel. School of Science, Macclesfield.
1884. †Agnew, Cornelius R. 266 Maddison-avenue, New York, U.S.A.
1902. †Agnew, Samuel, M.D. Bengal-place, Lurgan.
1864. *Ainsworth, David. The Flosh, Cleator, Carnforth.
1871. *Ainsworth, John Stirling. Harecroft, Gosforth, Cumberland.
1871. †Ainsworth, William M. The Flosh, Cleator, Carnforth.
1895. *Airy, Hubert, M.D. Stoke House, Woodbridge, Suffolk.
1891. *Aisbitt, M. W. Mountstuart-square, Cardiff.
1871. §Aitken, John, LL.D., F.R.S., F.R.S.E. Ardenlea, Falkirk, N.B.
1901. §Aitken, Thomas. County Buildings, Cupar, Fife.
1898. †Akers-Douglas, Right Hon. A., M.P. 106 Mount-street, W.
1884. *Alabaster, H. Milton, Grange-road, Sutton, Surrey.
1886. *Albright, G. S. The Elms, Edgbaston, Birmingham.
1900. *Aldren, Francis J., M.A. The Lizans, Malvern Link.
1896. §Aldridge, J. G. W., Assoc.M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1894. †Alexander, A. W. Blackwall Lodge, Halifax.
1891. †Alexander, D. T. Dynas Powis, Cardiff.
1883. †Alexander, George. Kildare-street Club, Dublin.
1888. *Alexander, Patrick Y. The Mount, Batheaston, Somerset.
1896. †Alexander, William. 45 Highfield South, Rockferry, Cheshire.
1891. *Alford, Charles J., F.G.S. 15 Great St. Helens, E.C.
1883. †Alger, W. H. The Manor House, Stoke Damerel, South Devon.
1883. †Alger, Mrs. W. H. The Manor House, Stoke Damerel, South Devon.
1867. †Alison, George L. C. Dundee.
1885. †Allan, David. West Cults, near Aberdeen.
1871. †Allan, G., M.Inst.C.E. 10 Austin Friars, E.C.
1901. *Allan, James A. Westerton, Milngavie.
1871. †Allen, Alfred H., F.C.S. 67 Surrey-street, Sheffield.
1879. *Allen, Rev. A. J. C. 34 Lensfield-road, Cambridge.

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1898. §ALLEN, Dr. E. J. The Laboratory, Citadel Hill, Plymouth.
1888. ‡ALLEN, F. J., M.A., M.D., Professor of Physiology. The University, Birmingham.
1884. ‡Allen, Rev. George. Shaw Vicarage, Oldham.
1891. ‡Allen, Henry A., F.G.S. Geological Museum, Jermyn-street, S.W.
1887. ‡Allen, John. 14 Park-road, St. Anne's-on-the-Sea, viâ Preston.
1878. ‡Allen, John Romilly. 28 Great Ormond-street, W.C.
1889. ‡*Allhusen, Alfred. Low Fell, Gateshead.*
1896. ‡Alsop, J. W. 16 Bidston-road, Oxton.
1882. *Alverstone, The Right Hon. Lord, G.C.M.G., LL.D., F.R.S. Hornton Lodge, Hornton-street, Kensington, W.
1887. ‡Alward, G. L. 11 Hamilton-street, Grimsby, Yorkshire.
1873. ‡Ambler, John. North Park-road, Bradford, Yorkshire.
1891. ‡Ambrose, D. R. Care of Messrs. J. Evans & Co., Bute Docks, Cardiff.
1883. §Amery, John Sparke. Druid, Ashburton, Devon.
1883. §Amery, Peter Fabyan Sparke. Druid, Ashburton, Devon.
1884. ‡AMI, HENRY, M.A., D.Sc., F.G.S. Geological Survey, Ottawa, Canada.
1883. ‡Anderson, Miss Constance. 17 Stonegate, York.
1885. *ANDERSON, HUGH KERR. Caius College, Cambridge.
1901. *Anderson, James. Ravelston, Kelvinside, Glasgow.
1874. ‡Anderson, John, J.P., F.G.S. Holywood, Belfast.
1892. ‡Anderson, Joseph, LL.D. 8 Great King-street, Edinburgh.
1899. *Anderson, Miss Mary K. 13 Napier-road, Edinburgh.
1888. *Anderson, R. Bruce. 35A Great George-street, S.W.
1887. ‡ANDERSON, Professor R. J., M.D., F.L.S. Queen's College, and Atlantic Lodge, Salthill, Galway.
1889. ‡Anderson, R. Simpson. Elswick Collieries, Newcastle-upon-Tyne.
1880. *ANDERSON, TEMPEST, M.D., B.Sc., F.G.S. (Local Sec. 1881). 17 Stonegate, York.
1902. *Anderson, Thomas. 41 Cliftonville-road, Belfast.
1901. *Anderson, Dr. W. Carrick. 2 Florentine-gardens, Glasgow.
1901. ‡Anderson, W. F. G. 47 Union-street, Glasgow.
1895. ‡Andrews, Charles W. British Museum (Natural History), S.W.
1891. ‡Andrews, Thomas. 163 Newport-road, Cardiff.
1880. *Andrews, Thornton, M.Inst.C.E. Cefn Eithen, Swansea.
1886. §Andrews, William, F.G.S. Steeple Croft, Coventry.
1883. ‡Anelay, Miss M. Mabel. Girton College, Cambridge.
1877. §ANGELL, JOHN, F.C.S., F.I.C. 6 Beacons-field, Derby-road, Withington, Manchester.
1886. ‡Annan, John, J.P. Whitmore Reans, Wolverhampton.
1900. ‡Annandale, Nelson. 34 Charlotte-square, Edinburgh.
1896. ‡Annett, R. C. F. 4 Buckingham-avenue, Sefton Park, Liverpool.
1886. ‡Ansell, Joseph. 38 Waterloo-street, Birmingham.
1878. ‡Anson, Frederick H. 15 Dean's-yard, Westminster, S.W.
1890. §Antrobus, J. Coutts. Eaton Hall, Congleton.
1901. ‡Arakawa, Minozi. Japanese Consulate, 84 Bishopsgate-street Within, E.C.
1900. §Arber, E. A. N., B.A. Trinity College, Cambridge.
1898. ‡*Archer, G. W.* 11 *All Saints'-road, Clifton, Bristol.*
1894. §Archibald, A. The Bank House, Ventnor.
1884. *Archibald, E. Douglas. 32 Shaftesbury-avenue, W.
1883. §Armistead, Richard. 17 Chambres-road, Southport.
1883. *Armistead, William. Hillcrest, Oaken, Wolverhampton.
1903. *ARMSTRONG, Dr. E. FRANKLAND. 55 Granville-park, Lewisham, S.E.

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1873. *ARMSTRONG, HENRY E., Ph.D., LL.D., F.R.S. (Pres. B, 1885; Pres. L, 1902; Council 1899–), Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 55 Granville-park, Lewisham, S.E.
1889. †Armstrong, Thomas John. 14 Hawthorn-terrace, Newcastle-upon-Tyne.
1893. †Arnold-Bemrose, H., M.A., F.G.S. 56 Friar-gate, Derby.
1901. †Arthur, Matthew. 78 Queen-street, Glasgow.
1870. *Ash, Dr. T. Linnington. Penroses, Holsworthy, North Devon.
1903. *Ashby, Thomas, jun. The British School, Rome.
1874. †Ashe, Isaac, M.B. Dundrum, Co. Dublin.
1889. †Ashley, Howard M. Airedale, Ferrybridge, Yorkshire.
1887. †Ashton, Thomas Gair, M.A. 36 Charlotte-street, Manchester.
Ashworth, Henry. Turton, near Bolton.
1903. §Ashworth, J. H., D.Sc. 4 Cluny-terrace, Edinburgh.
1888. *Ashworth, J. Jackson. Kingston House, Didsbury, near Manchester.
1890. †Ashworth, J. Reginald, B.Sc. 105 Freehold-street, Rochdale.
1887. †Ashworth, John Wallwork, F.G.S. Thorne Bank, Heaton Moor, Stockport.
1887. †Ashworth, Mrs. J. W. Thorne Bank, Heaton Moor, Stockport.
1875. *Aspland, W. Gaskell. Tuplins, Newton Abbot.
1896. *Assheton, Richard. Grantchester, Cambridge.
1903. §Atchison, Arthur F. T., B.Sc. Royal Engineering College, Cooper's Hill, Staines.
1896. §Atkin, George, J.P. Egerton Park, Rockferry.
1887. §Atkinson, Rev. C. Chetwynd, D.D. Ingestre, Ashton-on-Mersey.
1898. *Atkinson, E. Cuthbert. Care of C. W. Atkinson, Esq., 31 Manor-road, Beckenham, Kent.
1894. †Atkinson, George M. 28 St. Oswald's-road, S.W.
1894. *Atkinson, Harold W. Boys' High School, Pretoria, South Africa.
1881. †Atkinson, J. T. The Quay, Selby, Yorkshire.
1881. †ATKINSON, ROBERT WILLIAM, F.C.S. (Local Sec. 1891). 44 Loudoun-square, Cardiff.
1894. §Atkinson, William. Erwood, Beckenham, Kent.
1863. *ATTFIELD, J., M.A., Ph.D., F.R.S., F.C.S. Ashlands, Watford, Herts.
1884. †Auchincloss, W. S. Atlantic Highlands, New Jersey, U.S.A.
1903. §AUSTIN, CHARLES E. 37 Cambridge-road, Southport.
1853. *AVEBURY, The Right Hon. Lord, D.C.L., F.R.S. (PRESIDENT, 1881; TRUSTEE, 1872– ; Pres. D, 1872; Council 1865–71). High Elms, Farnborough, Kent.
1901. §Aveling, T. C. 32 Bristol-street, Birmingham.
1877. *AYRTON, W. E., F.R.S. (Pres. A, 1898; Council 1889–96), Professor of Electrical Engineering in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 41 Kensington Park-gardens, W.

1884. †Baby, The Hon. G. Montreal, Canada.
1900. †BACCHUS, RAMSDEN (Local Sec. 1900). 15 Welbury-drive, Bradford.
1883. *Bach, Madame Henri. 12 Rue Fénélon, Lyons.
Backhouse, Edmund. Darlington.
1863. †Backhouse, T. W. West Hendon House, Sunderland.
1883. *Backhouse, W. A. St. John's, Wolsingham, R.S.O., Durham.
1887. *Bacon, Thomas Walter. Ramsden Hall, Billericay, Essex.
1887. †Baddeley, John. 1 Charlotte-street, Manchester.
1903. §Baden-Powell, Major B. 22 Prince's-gate, S.W.
1883. †Bagnold, Mrs. Berkeley House, High Park, Ryde, Isle of Wight.
1883. †Baildon, Dr. 42 Hoghton-street, Southport.

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Year of Election.

1892. ‡Baildon, H. Bellyse. Duncliffe, Murrayfield, Edinburgh.
1883. *Bailey, Charles, F.L.S. Atherstone House, North-drive, St. Anne's-on-the-Sea, Lancashire.
1893. §Bailey, Colonel F., Sec. R.Scot.G.S., F.R.G.S. 7 Drummond-place, Edinburgh.
1870. ‡Bailey, Dr. Francis J. 51 Grove-street, Liverpool.
1887. *Bailey, G. H., D.Sc., Ph.D. Marple Cottage, Marple, Cheshire.
1899. ‡Bailey, T. Lewis. Fernhill, Formby, Lancashire.
1855. ‡Bailey, W. Horseley Fields Chemical Works, Wolverhampton.
1894. *Baily, Francis Gibson, M.A. 11 Ramsay-garden, Edinburgh.
1878. ‡Baily, Walter. 4 Roslyn-hill, Hampstead, N.W.
1897. §Bain, James, jun. Toronto.
1885. ‡Bain, William N. Collingwood, Pollokshields, Glasgow.
1882. *Baker, Sir Benjamin, K.C.B., K.C.M.G., LL.D., D.Sc., F.R.S., M.Inst.C.E. (Pres. G, 1885; Council, 1889–96). 2 Queen Square-place, Westminster, S.W.
1886. §Baker, Harry, F.I.C. Epworth House, Moughland-lane, Runcorn.
1898. ‡Baker, Herbert M. Wallcroft, Durdham Park, Clifton, Bristol.
1898. ‡Baker, Hiatt C. Mary-le-Port-street, Bristol.
1881. ‡Baker, Robert, M.D. The Retreat, York.
1875. ‡Baker, W. Proctor. Bristol.
1881. ‡Baldwin, Rev. G. W. de Courcy, M.A. Warshill Vicarage, York.
1884. ‡Balete, Professor E. Polytechnic School, Montreal, Canada.
1904. §Balfour, The Right Hon. A. J., D.C.L., M.P., F.R.S., Chancellor of the University of Edinburgh. (President Elect.) 10 Downing-street, S.W.
1871. ‡Balfour, The Right Hon. G.W., M.P. 24 Addison-road, Kensington, W.
1894. §Balfour, Henry, M.A. 11 Norham-gardens, Oxford.
1875. ‡Balfour, Isaac Bayley, M.A., D.Sc., M.D., F.R.S., F.R.S.E., F.L.S., (Pres. D, 1894; K, 1901), Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1878. *Ball, Charles Bent, M.D., Regius Professor of Surgery in the University of Dublin. 24 Merrion-square, Dublin.
1866. *Ball, Sir Robert Stawell, LL.D., F.R.S., F.R.A.S. (Pres. A, 1887; Council 1884–90, 1892–94; Local Sec. 1878), Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.
1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1886. ‡Ballantyne, J. W., M.B. 24 Melville-street, Edinburgh.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1890. ‡Bamford, Professor Harry, B.Sc. 3 Albany-street, Glasgow.
1899. ‡Bampton, Mrs. 42 Marine-parade, Dover.
1882. ‡Bance, Colonel Edward, J.P. Oak Mount, Highfield, Southampton.
1898. ‡Bannerman, W. Bruce, F.R.G.S., F.G.S. The Lindens, Sydenham-road, Croydon.
1884. ‡Barbeau, E. J. Montreal, Canada.
1866. ‡Barber, John. Long-row, Nottingham.
1890. *Barber-Starkey, W. J. S. Aldenham Park, Bridgnorth, Salop.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1887. *Barclay, Robert. Sedgley New Hall, Prestwich, Manchester.
1886. ‡Barclay, Thomas. 17 Bull-street, Birmingham.
1902. ‡Barcroft, H., D.L. The Glen, Newry, Co. Down.
1902. §Barcroft, Joseph, M.A., B.Sc. King's College, Cambridge.

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Year of Election.

1881. ‡Barfoot, William, J.P. Whelford-place, Leicester.
1882. ‡Barford, J. D. Above Bar, Southampton.
1890. ‡Barker, Alfred, M.A., B.Sc. Aske's Hatcham School, New Cross, S.E.
1899 §Barker, John H. 22 Cardington-road, Bedford.
1882. *Barker, Miss J. M. 18 Claremont-place, Newcastle-on-Tyne.
1879. *Barker, Rev. Philip C., M.A., LL.B. Priddy Vicarage, Wells, Somerset.
1898. §Barker, W. R. 106 Redland-road, Bristol.
1886. ‡Barling, Gilbert. 85 Edmund-street, Edgbaston, Birmingham.
1873. ‡Barlow, Crawford, B.A., M.Inst.C.E. Deene, Tooting Bec-road, Streatham, S.W.
1889. §Barlow, H. W. L., M.A., M.B., F.C.S. The Park Hospital, Hither Green, S.E.
1883. ‡Barlow, J. J. 48 Part-street, Southport.
1878. ‡Barlow, John, M.D., Professor of Physiology in St. Mungo's College, Glasgow.
1883. ‡Barlow, John R. Greenthorne, near Bolton.
1885. *Barlow, William, F.G.S. The Red House, Great Stanmore.
1902. §Barnard, J. E. Jenner Institute of Preventive Medicine, Chelsea-gardens, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1881. ‡Barnard, William, LL.B. 3 New-court, Lincoln's Inn, W.C.
1889. ‡Barnes, J. W. Bank, Durham.
1868. §Barnes, Richard H. Heatherlands House, Parkstone, Dorset.
1899. ‡Barnes, Robert. 9 Kildare-gardens, Bayswater, W.
1884. ‡Barnett, J. D. Port Hope, Ontario, Canada.
1901. ‡Barnett, P. A. Pietermaritzburg, South Africa.
1890. ‡Barnett, W. D. 41 Threadneedle-street, E.C.
1881. ‡Barr, Archibald, D.Sc., M.Inst.C.E., Professor of Civil Engineering in the University, Glasgow.
1890. ‡Barr, Frederick H. 4 South-parade, Leeds.
1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.
1902. *Barr, Mark. 25 Kensington Court-gardens, W.
1891. ‡Barrell, Frank R., M.A., Professor of Mathematics in University College, Bristol.
1883. ‡Barrett, Mrs. J. C. Errismore, Birkdale, Southport.
1872. *Barrett, W. F., F.R.S., F.R.S.E., M.R.I.A., Professor of Physics in the Royal College of Science, Dublin.
1883. ‡Barrett, William Scott. Abbotsgate, Huyton, near Liverpool.
1899. ‡Barrett-Hamilton, Captain G. E. H. Kilmannock House, Arthurstown, Waterford, Ireland.
1887. ‡Barrington, Miss Amy. 18 Bradley-gardens, West Ealing, W.
1874. *Barrington, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.
1874. *Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. Thorneloe Lodge, Worcester.
1885. *Barron, Frederick Cadogan, M.Inst.C.E. Nervion, Beckenham-grove, Shortlands, Kent.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1893. *Barrow, George, F.G.S. Geological Survey Office, 28 Jermyn-street, S.W.
1886. ‡Barrow, George William. Baldraud, Lancaster.
1886. ‡Barrow, Richard Bradbury. Lawn House, 13 Ampton-road, Edgbaston, Birmingham.
1896. §Barrowman, James. Staneacre, Hamilton, N.B.
1886. ‡Barrows, Joseph, jun. Ferndale, Harborne-road, Edgbaston, Birmingham.

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Year of Election.

1858. ‡BARRY, Right Rev. ALFRED, D.D., D.C.L. The Cloisters, Windsor.
1883. ‡*Barry, Charles E.* 1 *Victoria-street, S.W.*
1881. ‡Barry, J. W. Duncombe-place, York.
1884. *Barstow, Miss Frances A. Garrow Hill, near York.
1890. *Barstow, J. J. Jackson. The Lodge, Weston-super-Mare.
1890. *Barstow, Mrs. The Lodge, Weston-super-Mare.
1892. ‡Bartholomew, John George, F.R.S.E., F.R.G.S. 12 Blacket-place, Edinburgh.
1858. *Bartholomew, William Hamond, M.Inst.C.E. Ridgeway House, Cumberland-road, Hyde Park, Leeds.
1884. ‡Bartlett, James Herbert. 148 Mansfield-street, Montreal, Canada.
1873. ‡Bartley, Sir G. C. T., K.C.B., M.P. St. Margaret's House, Victoria-street, S.W.
1892. ‡Barton, Miss. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1893. ‡Barton, Edwin H., B.Sc. University College, Nottingham.
1884. ‡Barton, H. M. Foster-place, Dublin.
1852. ‡Barton, James, B.A., M.Inst.C.E. Farndreg, Dundalk.
1892. ‡Barton, William. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1887. ‡Bartrum, John S. 13 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1898. ‡Bason, Vernon Millward. 7 Princess-buildings, Clifton, Bristol.
1876. ‡Bassano, Alexander. 12 Montagu-place, W.
1888. *BASSET, A. B., M.A., F.R.S. Fledborough Hall, Holyport, Berkshire.
1891. ‡Bassett, A. B. Cheverell, Llandaff.
1866. *BASSETT, HENRY. 26 Belitha-villas, Barnsbury, N.
1889. ‡BASTABLE, Professor C. F., M.A., F.S.S. (Pres. F, 1894). 6 Trevelyan-terrace, Rathgar, Co. Dublin.
1869. ‡*Bastard, S. S. Summerland-place, Exeter.*
1871. ‡BASTIAN, H. CHARLTON, M.A., M.D., F.R.S., F.L.S., Emeritus Professor of the Principles and Practice of Medicine in University College, London. 8A Manchester-square, W.
1889. ‡*Batalha-Reis, J. Portuguese Consulate, Newcastle-upon-Tyne.*
1883. ‡BATEMAN, Sir A. E., K.C.M.G., Controller-General Statistical Department, Board of Trade, 7 Whitehall-gardens, S.W.
1868. ‡Bateman, Sir F., M.D., LL.D. Upper St. Giles's-street, Norwich.
1889. ‡Bates, C. J. Heddon, Wylam, Northumberland.
1884. ‡BATESON, WILLIAM, M.A., F.R.S. St. John's College, Cambridge.
1881. *BATHER, FRANCIS ARTHUR, M.A., D.Sc., F.G.S. British Museum (Natural History), S.W.
1863. §BAUERMAN, H., F.G.S. 14 Cavendish-road, Balham, S.W.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1892. ‡Bayly, F. W. 8 Royal Mint, E.
1875. *Bayly, Robert. Torr Grove, near Plymouth.
1876. *BAYNES, ROBERT E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 2 Norham-gardens, Oxford.
1883. *Bazley, Gardner S. Hatherop Castle, Fairford, Gloucestershire.
Bazley, Sir Thomas Sebastian, Bart., M.A. Winterdyne, Chine Crescent-road, Bournemouth.
1886. ‡Beale, C. Calle Progress No. 83, Rosario de Santa Fé, Argentine Republic.
1886. ‡Beale, Charles G. Maple Bank, Edgbaston, Birmingham.
1860. *BEALE, LIONEL S., M.B., F.R.S. 61 Grosvenor-street, W.
1884. ‡Beamish, G. H.M. Prison, Liverpool.
1872. ‡Beanes, Edward, F.C.S. Moatlands, Paddock Wood, Brenchley, Kent.
1883. ‡Beard, Mrs. Oxford.
1889. §BEARE, Professor T. HUDSON, B.Sc., F.R.S.E., M.Inst.C.E. The University, Edinburgh.

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Year of Election.

1842. *Beatson, William. 2 Ash-mount, Rotherham.
1889. ‡Beattie, John. 5 Summerhill-grove, Newcastle-upon-Tyne.
1902. ‡Beatty, H. M., LL.D. Ballymena, Co. Antrim.
1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.R.M.S., F.S.S. 18 Piccadilly, W.
1886. ‡Beaugrand, M. H. Montreal, Canada.
1900. ‡Beaumont, Professor Roberts, M.I.Mech.E. Yorkshire College, Leeds.
1861. *Beaumont, Rev. Thomas George. Oakley Lodge, Leamington.
1887. *Beaumont, W. J. The Laboratory, Citadel Hill, Plymouth.
1885. *Beaumont, W. W., M.Inst.C.E. Outer Temple, 222 Strand, W.C.
1896. ‡Beazer, C. Hindley, near Wigan.
1887. *Beckett, John Hampden. Corbar Hall, Buxton, Derbyshire.
1885. ‡Beddard, Frank E., M.A., F.R.S., F.Z.S., Prosector to the Zoological Society of London, Regent's Park, N.W.
1870. §Beddoe, John, M.D., F.R.S. (Council, 1870–75). The Chantry, Bradford-on-Avon.
1890. ‡Bedford, James E., F.G.S. Shireoak-road, Leeds.
1891. §Bedlington, Richard. Gadlys House, Aberdare.
1878. ‡Bedson, P. Phillips, D.Sc., F.C.S. (Local Sec. 1889), Professor of Chemistry in the College of Physical Science, Newcastle-upon-Tyne.
1884. ‡Beers, W. G., M.D. 34 Beaver Hall-terrace, Montreal, Canada.
1873. ‡Behrens, Jacob. Springfield House, North-parade, Bradford, Yorkshire.
1901. *Beilby, George T. 11 University-gardens, Glasgow.
1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.
1891. *Belinfante, L. L., M.Sc., Assist.-Sec. G.S. Burlington House, W.
1892. ‡Bell, A. Beatson. 17 Lansdowne-crescent, Edinburgh.
1871. ‡Bell, Charles B. 6 Spring-bank, Hull.
1884. ‡Bell, Charles Napier. Winnipeg, Canada.
1894. ‡Bell, F. Jeffrey, M.A., F.Z.S. 35 Cambridge-street, Hyde Park, W.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1860. ‡Bell, Rev. George Charles, M.A. Marlborough College, Wilts.
1900. *Bell, H. Wilkinson. Holmehurst, Rawdon, near Leeds.
1862. *Bell, Sir Isaac Lowthian, Bart., LL.D., F.R.S., F.C.S., M.Inst.C.E. (Pres. B, 1889). Rounton Grange, Northallerton.
1875. ‡Bell, James, C.B., D.Sc., Ph.D., F.R.S. 52 Cromwell-road, Hove, Brighton.
1896. ‡Bell, James. Care of the Liverpool Steam Tug Co., Limited, Chapel-chambers, 28 Chapel-street, Liverpool.
1871. *Bell, J. Carter, F.C.S. Bankfield, The Cliff, Higher Broughton, Manchester.
1883. *Bell, John Henry. Bank House, Mirfield, Yorkshire.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.
1893. ‡Belper, The Right Hon. Lord, LL.M. Kingston, Nottinghamshire.
1884. ‡Bemrose, Joseph. 15 Plateau-street, Montreal, Canada.
1885. ‡Benham, William Blaxland, D.Sc., Professor of Biology in the University of Otago, New Zealand.
1891. ‡*Bennett, Alfred Rosling.* 44 *Manor Park-road, Harlesden, N.W.*
1896. ‡Bennett, George W. West Ridge, Oxton, Cheshire.
1881. ‡Bennett, John Ryan. 3 Upper Belgrave-road, Clifton, Bristol.
1883. *Bennett, Laurence Henry. The Elms, Paignton, South Devon.
1901. §Bennett, Professor Peter. 6 Kelvinhaugh-street, Sandyford, Glasgow.

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Year of Election.

1896. ‡Bennett, Richard. 19 Brunswick-street, Liverpool.
1881. ‡Bennett, Rev. S. H., M.A. St. Mary's Vicarage, Bishopshill Junior, York.
1903. §Benson, D. E. 18 Lansdowne-road, Southport.
1889. ‡Benson, John G. 12 Grey-street, Newcastle-upon-Tyne.
1901. *Benson, Miss Margaret J., D.Sc. Royal Holloway College, Egham.
1887. *Benson, Mrs. W. J. Care of W. J. Benson, Esq., Standard Bank, Johannesburg, Transvaal.
1863. ‡Benson, William. Fourstones Court, Newcastle-upon-Tyne.
1898. *Bent, Mrs. Theodore. 13 Great Cumberland-place, W.
1884. ‡Bentham, William. 724 Sherbrooke-street, Montreal, Canada.
1897. ‡Bently, R. R. 97 Dowling-avenue, Toronto, Canada.
1896. *Bergin, William, M.A., Professor of Natural Philosophy in Queen's College, Cork.
1901. ‡Bergins, Walter L. 8 Marlborough-terrace, Glasgow.
1894. §Berkeley, The Right Hon. the Earl of, F.G.S. Foxcombe, Boarshill, near Abingdon.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1886. ‡Bernard, W. Leigh. Calgary, Canada.
1898. §Berridge, Miss C. E. 89 Goldhurst-terrace, Finchley-road, N.W.
1894. §Berridge, Douglas, M.A., F.C.S. The College, Malvern.
1862. ‡Besant, William Henry, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1882. *Bessemer, Henry. Moorlands, Bitterne, Southampton.
1890. ‡*Best, William Woodham.* 31 *Lyddon-terrace, Leeds.*
1880. *Bevan, Rev. James Oliver, M.A., F.S.A., F.G.S. Chillenden Rectory, Dover.
1885. ‡Beveridge, R. Beath Villa, Ferryhill, Aberdeen.
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1903. §Bickerdike, C. F. 1 Boveney-road, Honor Oak Park, S.E.
1870. ‡*Bickerton, A. W. Newland-terrace, Queen's-road, Battersea, S. W.*
1888. *Bidder, George Parker. Savile Club, Piccadilly, W.
1885. *Bidwell, Shelford, Sc.D., LL.B., F.R.S. Riverstone Lodge, Southfields, Wandsworth, Surrey, S.W.
1882. §Biggs, C. H. W., F.C.S. Glebe Lodge, Champion Hill, S.E.
1898. §Billington, Charles. Studleigh, Longport, Staffordshire.
1901. *Bilsland, William, J.P. 28 Park-circus, Glasgow.
1886. ‡Bindloss, G. F. Carnforth, Brondesbury Park, N.W.
1887. *Bindloss, James B. Elm Bank, Buxton.
1884. *Bingham, Colonel Sir John E., Bart. West Lea, Ranmoor, Sheffield.
1881. ‡Binnie, Sir Alexander R., M.Inst.C.E., F.G.S. (Pres. G, 1900). 77 Ladbroke-grove, W.
1900. ‡Bird, F. J. Norton House, Midsomer Norton, Bath.
1880. ‡Bird, Henry, F.C.S. South Down House, Millbrook, near Devonport.
1888. *Birley, Miss Caroline. 14 Brunswick-gardens, Kensington, W.
1887. *Birley, H. K. Hospital, Chorley, Lancashire.
1894. ‡Bisset, James, F.R.S.E. 9 Greenhill-park, Edinburgh.
1885. ‡Bissett, J. P. Wyndem, Banchory, N.B.
1886. *Bixby, Major W. H. Engineer's Office, Jones Building, Detroit, Michigan, U.S.A.
1901. ‡Black, John Albert. Lagarie-row, Helensburgh, N.B.
1889. ‡Black, W. 1 Lovaine-place, Newcastle-upon-Tyne.
1881. ‡Black, Surgeon-Major William Galt, F.R.C.S.E. Caledonian United Service Club, Edinburgh.
1901. §Black, W. P. M. 136 Wellington-street, Glasgow.

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Year of Election.

1876. ‡Blackburn, Hugh, M.A. Roshven, Fort William, N.B.
1884. ‡Blackburn, Robert. New Edinburgh, Ontario, Canada.
1900. ‡Blackburn, W. Owen. 3 Mount Royd, Bradford.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1855. *Blackie, W. G., Ph.D., F.R.G.S. (Local Sec. 1876). 1 Belhaven-terrace, Kelvinside, Glasgow.
1884. ‡Blacklock, Frederick W. 25 St. Famille-street, Montreal, Canada.
1903. *Blackman, F. F., M.A., D.Sc. St. John's College, Cambridge.
1896. ‡*Blackwood, J. M.* 16 *Oil-street, Liverpool.*
1886. ‡Blaikie, John, F.L.S. The Bridge House, Newcastle, Staffordshire.
1895. ‡Blaikie, W. B. 6 Belgrave-crescent, Edinburgh.
1883. ‡Blair, Mrs. Oakshaw, Paisley.
1892. ‡Blair, Alexander. 35 Moray-place, Edinburgh.
1892. ‡Blair, John. 9 Ettrick-road, Edinburgh.
1883. *Blake, Rev. J. F., M.A., F.G.S. 35 Harlesden-gardens, N.W.
1902. ‡Blake, Robert F., F.I.C. 66 Malone-avenue, Belfast.
1891. ‡Blakesley, Thomas H., M.A., M.Inst.C.E. Royal Naval College, Greenwich, S.E.
1894. ‡Blakiston, Rev. C. D. Exwick Vicarage, Exeter.
1900. *Blamires, Joseph. Bradley Lodge, Huddersfield.
1881. ‡Blamires, Thomas H. Close Hill, Lockwood, near Huddersfield.
1895. ‡Blamires, William. Oak House, Taylor Hill, Huddersfield.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1869. ‡Blanford, W. T., C.I.E., LL.D., F.R.S., F.G.S., F.R.G.S. (Pres. C, 1884; Council 1885-91). 72 Bedford-gardens, Campden Hill, W.
1887. *Bles, A. J. S. Palm House, Park-lane, Higher Broughton, Manchester.
1887. *Bles, Edward J., M.A., B.Sc. The University, Glasgow.
1887. ‡Bles, Marcus S. The Beeches, Broughton Park, Manchester.
1884. *Blish, William G. Niles, Michigan, U.S.A.
1902. ‡Blount, Bertram, F.I.C. 76 & 78 York-street, Westminster, S.W.
1888. ‡Bloxsom, Martin, B.A., Assoc.M.Inst.C.E. Hazelwood, Crumpsall Green, Manchester.
1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby.
Blyth, B. Hall. 135 George-street, Edinburgh.
1885. ‡Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College, Glasgow.
1867. *Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1887. ‡Blythe, William S. 65 Mosley-street, Manchester.
1901. §Blythswood, The Right Hon. Lord, LL.D. Blythswood, Renfrew.
1870. ‡Boardman, Edward. Oak House, Eaton, Norwich.
1887. *Boddington, Henry. Pownall Hall, Wilmslow, Manchester.
1900. ‡Bodington, Principal N., Litt.D. Yorkshire College, Leeds.
1889. ‡Bodmer, G. R., Assoc.M.Inst.C.E. 53 Victoria-street, S.W.
1884. ‡Body, Rev. C. W. E., M.A. Trinity College, Toronto, Canada.
1900. §Boileau, Lieut.-Colonel A. C. T., R.A. Royal Artillery Institution, Woolwich.
1887. *Boissevain, Gideon Maria. 4 Tesselschade-straat, Amsterdam.
1898. §Bolton, H., F.R.S.E. The Museum, Queen's-road, Bristol.
1894. §Bolton, John. 15 Cranley-gardens, Highgate, N.
1898. ‡Bolton, J. W. Baldwin-street, Bristol.
1898. §Bonar, J., M.A., LL.D. (Pres. F, 1898; Council 1899–). 1 Redington-road, Hampstead, N.W.
1883. ‡Bonney, Frederic, F.R.G.S. Colton House, Rugeley, Staffordshire.

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Year of election.

1871. *Bonney, Rev. Thomas George, D.Sc., LL.D., F.R.S., F.S.A., F.G.S. (Secretary, 1881–85; Pres. C, 1886). 23 Denning-road, Hampstead, N.W.
1888. ‡Boon, William. Coventry.
1893. ‡Boot, Jesse. Carlyle House, 18 Burns-street, Nottingham.
1890. *Booth, Charles, D.Sc., F.R.S., F.S.S. 24 Great Cumberland-place, W.
1883. ‡Booth, James. Hazelhurst, Turton.
1883. ‡*Booth, Richard. 4 Stone-buildings, Lincoln's Inn, W.C.*
1876. ‡Booth, Rev. William H. St. Paul's Rectory, Old Charlton, Kent.
1883. ‡Boothroyd, Benjamin. Weston-super-Mare.
1901. *Boothroyd, Herbert E., M.A., B.Sc. Sidney Sussex College, Cambridge.
1900. ‡*Borchgrevink, C. E. Lindfield, Sussex.*
1882. §Borns, Henry, Ph.D., F.C.S. 19 Alexandra-road, Wimbledon, Surrey.
1901. ‡Borradaile, L. A. Selwyn College, Cambridge.
1876. *Bosanquet, R. H. M., M.A., F.R.S., F.R.A.S. Castillo Zamora, Realejo-Alto, Teneriffe.
1903. §Bosanquet, Robert C. Rock Hall, Alnwick.
1896. ‡Bose, Professor J. C., C.I.E., M.A., D.Sc. Calcutta, India.
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
1903. §Boston, Herbert. 3 Belgrave-road, Birkdale, Lancashire.
1881. §Bothamley, Charles H., F.I.C., F.C.S., Director of Technical Instruction, Somerset County Education Committee. Hurst Knoll, Weston-super-Mare.
1887. ‡*Bott, Dr. Owens College, Manchester.*
1872. ‡Bottle, Alexander. 4 Godwyne-road, Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1887. ‡Bottomley, James, D.Sc., B.A. 220 Lower Broughton-road, Manchester.
1871. *Bottomley, James Thomson, M.A., D.Sc., F.R.S., F.R.S.E., F.C.S. 13 University-gardens, Glasgow.
1884. *Bottomley, Mrs. 13 University-gardens, Glasgow.
1892. ‡Bottomley, W. B., B.A., Professor of Botany in King's College, W.C.
1876. ‡Bottomley, William, jun. 15 University-gardens, Glasgow.
1890. ‡Boulnois, Henry Percy, M.Inst.C.E. 44 Campden House Court, Kensington, W.
1903. §Boulton, W. S. 2 Kymin-terrace, Penarth.
1883. ‡Bourdas, Isaiah. Dunoon House, Clapham Common, S.W.
1883. ‡Bourne, A. G., D.Sc., F.R.S., F.L.S., Professor of Biology in the Presidency College, Madras.
1893. *Bourne, G. C., M.A., F.L.S. (Council, 1903– ; Local Sec. 1894) Savile House, Mansfield-road, Oxford.
1890. ‡Bousfield, C. E. 55 Clarendon-road, Leeds.
1902. ‡Bousfield, William. 20 Hyde Park-gate, W.
1898. ‡Bovey, Edward P., jun. Clifton-grove, Torquay.
1884. ‡Bovey, Henry T., M.A., F.R.S., M.Inst.C.E., Professor of Civil Engineering and Applied Mechanics in McGill University, Montreal. Ontario-avenue, Montreal, Canada.
1888. ‡Bowden, Rev. G. New Kingswood School, Lansdown, Bath.
1881. *Bower, F. O., D.Sc., F.R.S., F.R.S.E., F.L.S. (Pres. K, 1898; Council 1900–), Regius Professor of Botany in the University of Glasgow.
1898. *Bowker, Arthur Frank, F.R.G.S., F.G.S. West Malling, Kent.
1856. *Bowlby, Miss F. E. 23 Lansdowne-parade, Cheltenham.
1898. §Bowley, A. L., M.A. Lynwood, Southern Hill, Reading.

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Year of Election.

1880. ‡Bowly, Christopher. Cirencester.
1887. †Bowly, Mrs. Christopher. Cirencester.
1899. *Bowman, Herbert Lister, M.A. Greenham Common, Newbury.
1899. *Bowman, John Herbert. Greenham Common, Newbury.
1887. §Box, Alfred Marshall. Care of Messrs. Cooper, Box, & Co., 69 Aldermanbury, E.C.
1895. *Boyce, Rubert, M.B., F.R.S., Professor of Pathology in the University of Liverpool.
1901. §Boyd, David T. Rhinsdale, Ballieston, Lanark.
1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.
1884. *Boyle, R. Vicars, C.S.I. 3 Stanhope-terrace, Hyde Park, W.
1892. §Boys, Charles Vernon, F.R.S. (Pres. A, 1903; Council, 1893–99). 27 The Grove, Boltons, S.W.
1872. *Brabrook, E. W., C.B., F.S.A. (Pres. H, 1898; Pres. F, 1903; Council, 1903–). 178 Bedford-hill, Balham, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Bushey Lodge, Teddington, Middlesex.
1894. *Braby, Ivon. Bushey Lodge, Teddington, Middlesex.
1893. §Bradley, F. L. Ingleside, Malvern Wells.
1899. *Bradley, J. W., Assoc.M.Inst.C.E., F.G.S. Westminster City Hall, Charing Cross-road, W.C.
1903. *Bradley, O. Charnock, M.B., F.R.S.E. Royal Veterinary College, Edinburgh.
1892. §Bradshaw, W. Carisbrooke House, The Park, Nottingham.
1863. ‡Brady, George S., M.D., LL.D., F.R.S., Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne. 2 Mowbray-villas, Sunderland.
1880. *Brady, Rev. Nicholas, M.A. Rainham Hall, Rainham, S.O., Essex.
1888. §Braikenridge, W. J., J.P. 16 Royal-crescent, Bath.
1898. ‡Bramble, Lieut.-Colonel James R., F.S.A. Seafield, Weston-super-Mare.
1867. ‡Brand, William. Milnefield, Dundee.
1861. *Brandreth, Rev. Henry. 72 Hills-road, Cambridge.
1885. *Bratby, William, J.P. Alton Lodge, Hale, Bowdon, Cheshire.
1902. §Braun, Henry C. 1 North-street, King's Cross, N.
1890. *Bray, George. Belmont, Wood-lane, Headingley, Leeds.
1868. ‡Bremridge, Elias. 17 Bloomsbury-square, W.C.
1902. *Brereton, Cloudesley. Breningham House, Melton Constable, Norfolk.
1898. §Brereton, Cuthbert A., M.Inst.C.E. 21 Delahay-street, S.W.
1882. *Bretherton, C. E. 12 The Paragon, Blackheath, S.E.
1866. ‡Brettell, Thomas. Dudley.
1891. ‡*Brice, Arthur Montefiore, F.G.S., F.R.G.S.* 28 *Addison-mansions, Kensington, W.*
1886. ‡Bridge, T. W., M.A., D.Sc., F.R.S., Professor of Zoology in the University of Birmingham.
1870. *Bridson, Joseph R. Holybourne, Alton, Hants.
1887. ‡Brierley, John, J.P. The Clough, Whitefield, Manchester.
1870. ‡Brierley, Joseph. New Market-street, Blackburn.
1886. ‡Brierley, Leonard. Somerset-road, Edgbaston, Birmingham.
1879. ‡Brierley, Morgan. Denshaw House, Saddleworth.
1870. *Brigg, John, M.P. Kildwick Hall, Keighley, Yorkshire.
1890. ‡Brigg, W. A. Kildwick Hall, Keighley, Yorkshire.
1893. ‡Bright, Joseph. Western-terrace, The Park, Nottingham.
1868. ‡*Brine, Admiral Lindesay, F.R.G.S. United Service Club, Pall Mall, S.W.*

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Year of Election.

1893. ‡Briscoe, Albert E., B.Sc., A.R.C.Sc. Municipal Technical Institute, Romford-road, West Ham, E.
1884. ‡Brisette, M. H. 424 St. Paul-street, Montreal, Canada.
1898. ‡Bristol, The Right Rev. G. F. Browne, D.D., Lord Bishop of. 17 The Avenue, Clifton, Bristol.
1879. *Brittain, W. H., J.P., F.R.G.S. Storth Oaks, Sheffield.
1878. ‡Britten, James, F.L.S. Department of Botany, British Museum, S.W.
1884. *Brittle, John R., M.Inst.C.E., F.R.S.E. 9 Vanbrugh-hill, Blackheath, S.E.
1899. ‡Broadwood, Miss Bertha M. Pleystowe, Capel, Surrey.
1899. ‡Broadwood, James H. E. Pleystowe, Capel, Surrey.
1897. ‡Brock, W. R. Toronto.
1896. *Brocklehurst, S. Olinda, Sefton Park, Liverpool.
1883. *Brodie, David, M.D. 68 Hamilton-road, Highbury, N.
1901. §Brodie, T. G. Examination Hall, Victoria Embankment, W.C.
1884. ‡Brodie, William, M.D. 64 Lafayette-avenue, Detroit, Michigan, U.S.A.
1901. ‡Brodie, W. Brodie, M.D., F.R.S.E. 28 Hamilton Park-terrace, Hillhead, Glasgow.
1883. *Brodie-Hall, Miss W. L. 5 Devonshire-place, Eastbourne.
1903. §Brodrick, Harold, M.A. (Local Sec., 1903). 7 Aughton-road, Southport.
1881. ‡Brook, Robert G. Wolverhampton House, St. Helens, Lancashire.
1864. *Brooke, Ven. Archdeacon J. Ingham. The Vicarage, Halifax.
1887. §Brooks, James Howard. Elm Hirst, Wilmslow, near Manchester.
1863. ‡Brooks, John Crosse. 14 Lovaine-place, Newcastle-on-Tyne.
1887. ‡Brooks, S. H. Slade House, Levenshulme, Manchester.
1883. *Brotherton, E. A., M.P. Arthington Hall, Wharfedale, viâ Leeds.
1901. §Brough, Bennett H., F.I.C., F.G.S. 28 Victoria-street, S.W.; and Cranleigh House, near Addlestone, Surrey.
1883. *Brough, Mrs. Charles S. 12 Hillcrest-road, Sydenham, S.E.
1886. ‡Brough, Professor Joseph, LL.M., Professor of Logic and Philosophy in University College, Aberystwith.
1863. *Brown, Alexander Crum, M.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1874; Local Sec. 1871), Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1892. ‡Brown, Andrew, M.Inst.C.E. Messrs. Wm. Simons & Co., Renfrew, near Glasgow.
1896. ‡Brown, A. T. The Nunnery, St. Michael's Hamlet, Liverpool.
1867. ‡Brown, Sir Charles Gage, M.D., K.C.M.G. 88 Sloane-street, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. ‡Brown, David. Willowbrae House, Midlothian.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1883. ‡Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1903. §Brown, F. W. 6 Rawlinson-road, Southport.
1881. ‡Brown, Frederick D. 26 St. Giles's-street, Oxford.
1883. ‡Brown, George Dransfield. Henley Villa, Ealing, Middlesex, W.
1883. *Brown, Mrs. H. Bienz. Overton, Crathes, Deeside, Aberdeen.
1883. ‡*Brown, Mrs. Helen. Canaan-grove, Newbattle-terrace, Edinburgh.*
1870. §Brown, Horace T., LL.D., F.R.S., F.G.S. (Pres. B, 1899). 52 Nevern-square, S.W.
1883. ‡*Brown, Miss Isabella Spring. Canaan-grove, Newbattle-terrace, Edinburgh.*

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Year of Election.

1870. *Brown, J. Campbell, D.Sc., F.C.S., Professor of Chemistry in the University of Liverpool.
1876. §Brown, John, F.R.S. (Local Sec. 1902). Longhurst, Dunmurry, Belfast.
1881. *Brown, John, M.D. 20 Warrender Park-crescent, Edinburgh.
1882. **Brown, John.* 7 *Second-avenue, Nottingham.*
1895. *Brown, John Charles. Burlington-road, Sherwood, Nottingham.
1894. ‡Brown, J. H. 6 Cambridge-road, Brighton.
1882. *Brown, Mrs. Mary. 20 Warrender Park-crescent, Edinburgh.
1898. §Brown, Nicol, F.G.S. 4 The Grove, Highgate, N.
1897. ‡Brown, Price, M.B. 37 Carlton-street, Toronto, Canada.
1886. ‡Brown, R., R.N. Laurel Bank, Barnhill, Perth.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-upon-Tyne.
1897. ‡Brown, Richard. Jarvis-street, Toronto, Canada.
1901. ‡Brown, R. N. R., B.Sc. University College, Dundee.
1896. ‡Brown, Stewart H. Quarry Bank, Allerton, Liverpool.
1891. §Brown, T. Forster, M.Inst.C.E. (Pres. G, 1891). Springfort, Stoke Bishop, Bristol.
1885. ‡Brown, W. A. The Court House, Aberdeen.
1884. ‡Brown, William George. Ivy, Albemarle Co., Virginia, U.S.A.
1863. ‡Browne, Sir Benjamin Chapman, M.Inst.C.E. Westacres, Newcastle-upon-Tyne.
1900. *Browne, Frank Balfour. The Cottage, Catfield, Great Yarmouth.
1895. *Browne, H. T. Doughty. 10 Hyde Park-terrace, W.
1879. ‡Browne, Sir J. Crichton, M.D., LL.D., F.R.S., F.R.S.E. 61 Carlisle-place-mansions, Victoria-street, S.W.
1891. ‡Browne, Montagu, F.G.S. Town Museum, Leicester.
1862. *Browne, Robert Clayton, M.A. Browne's Hill, Carlow, Ireland.
1872. ‡Browne, R. Mackley, F.G.S. Redcot, Bradbourne, Sevenoaks, Kent.
1902. §Browne, W. J., M.A., M.R.I.A. Templemore Park, Londonderry.
1865. ‡Browning, John, F.R.A.S. 78 Strand, W.C.
1883. ‡Browning, Oscar, M.A. King's College, Cambridge.
1892. ‡Bruce, James. 10 Hill-street, Edinburgh.
1901. ‡Bruce, John. Inverallan, Helensburgh.
1893. ‡Bruce, William S. 11 Mount Pleasant, Joppa, Edinburgh.
1902. ‡*Bruce-Kingsmill, Captain J., R.A. Royal Arsenal, Woolwich.*
1900. *Brumm, Charles. Lismara, Grosvenor-road, Birkdale, Southport.
1863. *Brunel, H. M., M.Inst.C.E. 21 Delahay-street, Westminster, S.W.
1875. ‡Brunlees, John, M.Inst.C.E. 12 Victoria-street, Westminster, S.W.
1896. *Brunner, Sir J. T., Bart., M.P. Druid's Cross, Wavertree, Liverpool.
1868. ‡Brunton, Sir T. Lauder, M.D., D.Sc., F.R.S. 10 Stratford-place, Oxford-street, W.
1897. *Brush, Charles F. Cleveland, Ohio, U.S.A.
1878. ‡Brutton, Joseph. Yeovil.
1886. *Bryan, G. H., D.Sc., F.R.S., Professor of Mathematics in University College, Bangor.
1894. ‡Bryan, Mrs. R. P. Plas Gwyn, Bangor.
1884. ‡Bryce, Rev. Professor George. Winnipeg, Canada.
1897. ‡Bryce, Right Hon. James, D.C.L., M.P., F.R.S. 54 Portland-place, W.
1901. §Bryce, Thomas H. 2 Granby-terrace, Hillhead, Glasgow.
1894. ‡Brydone, R. M. Petworth, Sussex.
1902. *Bubb, Miss E. Maude. Ullenwood, near Cheltenham.
1890. §Bubb, Henry. Ullenwood, near Cheltenham.
1871. §Buchan, Alexander, M.A., LL.D., F.R.S., F.R.S.E., Sec. Scottish Meteorological Society. 42 Heriot-row, Edinburgh.

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Year of election.

1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
1902. *Buchanan, Miss Florence, D.Sc. University Museum, Oxford.
1901. ‡Buchanan, James, M.D. 12 Hamilton-drive, Maxwell Park, Glasgow.
1881. *Buchanan, John H., M.D. Sowerby, Thirsk.
1871. ‡Buchanan, John Young, M.A., F.R.S., F.R.S.E., F.R.G.S., F.C.S. Christ's College, Cambridge.
1884. ‡Buchanan, W. Frederick. Winnipeg, Canada.
1883. ‡Buckland, Miss A. W. 5 Beaumont-crescent, West Kensington, W.
1886. *Buckle, Edmund W. 23 Bedford-row, W.C.
1886. ‡Buckley, Samuel. Merlewood, Beaver Park, Didsbury.
1884. *Buckmaster, Charles Alexander, M.A., F.C.S. 16 Heathfield-road, Mill Hill Park, W.
1851. *Buckton, George Bowdler, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1887. ‡Budenberg, C. F., B.Sc. Buckau Villa, Demesne-road, Whalley Range, Manchester.
1901. ‡Budgett, J. S. Trinity College, Cambridge.
1875. ‡Budgett, Samuel. Penryn, Beckenham, Kent.
1883. ‡Buick, Rev. George R., M.A. Cullybackey, Co. Antrim, Ireland.
1893. §Bulleid, Arthur, F.S.A. The Old Vicarage, Midsomer Norton, Bath.
1903. *Bullen, Rev. R. Ashington. Pyrford Vicarage, Woking, Surrey.
1871. ‡Bulloch, Matthew. 48 Prince's-gate, S.W.
1883. ‡Bulpit, Rev. W. T. Crossens Rectory, Southport.
1895. ‡Bunte, Dr. Hans. Karlsruhe, Baden.
1886. §Burbury, S. H., M.A., F.R.S. 1 New-square, Lincoln's Inn, W.C.
1842. *Burd, John. Glen Lodge, Knocknerea, Sligo.
1869. ‡Burdett-Coutts, Baroness. 1 Stratton-street, Piccadilly, W.
1881. ‡Burdett-Coutts, William Lehmann, M.P. 1 Stratton-street, Piccadilly, W.
1891. ‡Burge, Very Rev. T. A. Ampleforth Cottage, near York.
1894. ‡Burke, John B. B. Trinity College, Cambridge.
1884. *Burland, Lieut.-Col. Jeffrey H. 824 Sherbrook-street, Montreal, Canada.
1899. ‡Burls, Herbert T. Care of Messrs. H. S. King & Co., Cornhill, E.C.
1888. ‡Burne, H. Holland. 28 Marlborough-buildings, Bath.
1883. *Burne, Major-General Sir Owen Tudor, G.C.I.E., K.C.S.I., F.R.G.S. 132 Sutherland-gardens, Maida Vale, W.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1885. *Burnett, W. Kendall, M.A. Migvie House, North Silver-street, Aberdeen.
1877. ‡Burns, David. Vallum View, Burgh-road, Carlisle.
1884. ‡Burns, Professor James Austin. Southern Medical College, Atlanta, Georgia, U.S.A.
1899. ‡Burr, Malcolm. Dorman's Park, East Grinstead.
1887. ‡Burroughs, Eggleston, M.D. Snow Hill-buildings, E.C.
1860. ‡Burrows, Montague, M.A. Oxford.
1894. ‡Burstall, H. F. W. 76 King's-road, Camden-road, N.W.
1891. ‡Burt, J. J. 103 Roath-road, Cardiff.
1888. ‡Burt, Sir John Mowlem. 3 St. John's-gardens, Kensington, W.
1888. ‡Burt, Lady. 3 St. John's-gardens, Kensington, W.
1894. ‡Burton, Charles V. 24 Wimpole-street, W.
1866. *Burton, Frederick M., F.L.S., F.G.S. Highfield, Gainsborough.
1889. ‡Burton, Rev. R. Lingen. Little Aston, Sutton Coldfield.
1897. ‡Burton, S. H., M.B. 50 St. Giles's-street, Norwich.
1892. ‡Burton-Brown, Colonel Alexander, R.A., F.R.A.S., F.G.S. 11 Union-crescent, Margate.

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Year of Election.

1897. ‡Burwash, Rev. N., LL.D., Principal of Victoria University, Toronto, Canada.
1887. *Bury, Henry. Mayfield House, Farnham, Surrey.
1899. §Bush, Anthony. 43 Portland-road, Nottingham.
1895. ‡Bushe, Colonel C. K., F.G.S. 19 Cromwell-road, S.W.
1878. ‡*Butcher, J. G., M.A. 22 Collingham-place, S.W.*
1884. *Butcher, William Deane, M.R.C.S.Eng. Holyrood, 5 Cleveland-road, Ealing, W.
1884. ‡Butler, Matthew I. Napanee, Ontario, Canada.
1884. *Butterworth, W. Park-avenue, Temperley, near Manchester.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1887. *Buxton, J. H. Clumber Cottage, Montague-road, Felixstowe.
1881. ‡Buxton, Sydney C., M.P. 15 Eaton-place, S.W.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1872. ‡Buxton, Sir Thomas Fowell, Bart., G.C.M.G., F.R.G.S. Warlies, Waltham Abbey, Essex.
1899. §Byles, Arthur R. 'Bradford Observer,' Bradford, Yorkshire.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1883. ‡Byrom, John R. The Rowans, Fairfield, near Manchester.

1889. ‡*Cackett, James Thoburn. 60 Larkspur-terrace, Newcastle-upon-Tyne.*
1892. ‡Cadell, Henry M., B.Sc., F.R.S.E. Grange, Bo'ness, N.B.
1894. ‡Caillard, Miss E. M. Wingfield House, near Trowbridge, Wilts.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. 8 Roseangle, Dundee.
1901. ‡Caldwell, Hugh. Blackwood, Newport, Monmouthshire.
1868. ‡Caley, A. J. Norwich.
1887. ‡Callaway, Charles, M.A., D.Sc., F.G.S. 16 Montpellier-villas, Cheltenham.
1897. §Callendar, Hugh L., M.A., LL.D., F.R.S. (Council, 1900-), Professor of Physics in the Royal College of Science. 2 Chester-place, Regent's Park, N.W.
1892. ‡Calvert, A. F., F.R.G.S. Royston, Eton-avenue, N.W.
1901. ‡Calvert, H. T. Roscoe-terrace, Armley, Leeds.
1884. ‡Cameron, Æneas. Yarmouth, Nova Scotia, Canada.
1857. ‡Cameron, Sir Charles A., C.B., M.D. 15 Pembroke-road, Dublin.
1896. §Cameron, Irving H. 307 Sherbourne-street, Toronto, Canada.
1884. ‡Cameron, James C., M.D. 41 Belmont-park, Montreal, Canada.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1901. §Campbell, Archibald. Springfield Quay, Glasgow.
1884. ‡Campbell, Archibald H. Toronto, Canada.
1876. ‡Campbell, Right Hon. James A., LL.D., M.P. Stracathro House, Brechin.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1897. ‡Campbell, Major J. C. L. New Club, Edinburgh.
1901. ‡Campbell, M. Pearce. 9 Lynedoch-crescent, Glasgow.
1898. ‡*Campbell, Mrs. Napier. 81 Ashley-gardens, S.W.*
1902. ‡Campbell, Robert. 21 Great Victoria-street, Belfast.
1897. †Campion, B. W. Queen's College, Cambridge.
1882. ‡Candy, F. H. 71 High-street, Southampton.
1890. ‡Cannan, Edwin, M.A., LL.D., F.S.S. (Pres. F, 1902). 46 Wellington-square, Oxford.
1897. §Cannon, Herbert. Woodbank, Erith, Kent.
1888. ‡Cappel, Sir Albert J. L., K.C.I.E. 27 Kensington Court-gardens, W.

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1894. §Capper, D. S., M.A., Professor of Mechanical Engineering in King's College, W.C.
1887. ‡Capstick, John Walton. Trinity College, Cambridge.
1873. *Carbutt, Sir Edward Hamer, Bart., M.Inst.C.E. 19 Hyde Park-gardens, W.
1896. *Carden, H. V. Fassaroe, Walmer.
1901. §Cargill, David Sime. 9 Park-terrace, Glasgow.
1877. ‡Carkeet, John. 3 St. Andrew's-place, Plymouth.
1898. ‡Carlile, George M. 7 Upper Belgrave-road, Bristol.
1901. ‡Carlile, W. Warrand. Harlie, Largs, Ayrshire.
1867. ‡Carmichael, David (Engineer). Dundee.
1876. ‡Carmichael, Niel, M.D. 177 Nitherdale-road, Pollokshields, Glasgow.
1897. ‡Carmichael, Norman R. Queen's University, Kingston, Ontario, Canada.
1884. ‡Carnegie, John. Peterborough, Ontario, Canada.
1902. ‡Carpenter, G. H., B.Sc. Science and Art Museum, Dublin.
1884. ‡Carpenter, Louis G. Agricultural College, Fort Collins, Colorado, U.S.A.
1897. ‡Carpenter, R. C. Cornell University, Ithaca, New York, U.S.A.
1889. ‡Carr, Cuthbert Ellison. Hedgeley, Alnwick.
1893. ‡Carr, J. Wesley, M.A., F.L.S., F.G.S., Professor of Biology in University College, Nottingham.
1889. ‡Carr-Ellison, John Ralph. Hedgeley, Alnwick.
1867. ‡Carruthers, William, F.R.S., F.L.S., F.G.S. (Pres. D, 1886). 14 Vermont-road, Norwood, S.E.
1886. ‡Carslake, J. Barham (Local Sec. 1886). 30 Westfield-road, Birmingham.
1890. ‡Carslaw, H. S., D.Sc., Professor of Mathematics in the University of Sydney, N.S.W.
1883. ‡Carson, John. 41 Royal-avenue, Belfast.
1903. *Cart, Rev. Henry. 49 Albert-court, Kensington Gore, S.W.
1868. *Carteighe, Michael, F.C.S., F.I.C. 180 New Bond-street, W.
1866. ‡*Carter, H. H. The Park, Nottingham.*
1870. ‡Carter, Dr. William. 78 Rodney-street, Liverpool.
1900. *Carter, Rev. W. Lower, M.A., F.G.S. Hopton, Mirfield.
1896. ‡Cartwright, Miss Edith G. 21 York Street-chambers, Bryanston-square, W.
1878. *Cartwright, Ernest H., M.A., M.D. 1 Bower-terrace, Maidstone.
1870. §Cartwright, Joshua, M.Inst.C.E., F.S.I. Peel-chambers, Market-place, Bury, Lancashire.
1862. ‡Carulla, F. J. R. 84 Rosehill-street, Derby.
1894. ‡Carus, Paul. La Salle, Illinois, U.S.A.
1884. *Carver, Rev. Canon Alfred J., D.D., F.R.G.S. Lynnhurst, Streatham Common, S.W.
1884. ‡Carver, Mrs. Lynnhurst, Streatham Common, S.W.
1901. ‡Carver, Thomas A. B., B.Sc., Assoc. M.Inst.C.E. 118 Napiershall-street, Glasgow.
1887. ‡Casartelli, Rev. L. C., M.A., Ph.D. St. Bede's College, Manchester.
1899. *Case, J. Monckton. Hampden Club, Phœnix-street, N.W.*
1897. *Case, Willard E. Auburn, New York, U.S.A.
1896. *Casey, James. 10 Philpot-lane, E.C.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 35 Commercial-street, Halifax.
1900. *Cassie, W., M.A., Professor of Physics in the Royal Holloway College. Brantwood, Englefield Green.

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Year of Election.

1897. ‡Caston, Harry Edmonds Featherston. 340 Brunswick-avenue, Toronto, Canada.
1874. ‡Caton, Richard, M.D. Lea Hall, Gateacre, Liverpool.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1886. *Cave-Moyle, Mrs. Isabella. 30 Promenade, Cheltenham.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1901. §Chamen, W. A. 66 Partickhill-road, Glasgow.
1881. *Champney, John E. 27 Hans-place, S.W.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. ‡Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1888. ‡Chandler, S. Whitty, B.A. Sherborne, Dorset.
1902. §Chapman, D. L. 10 Parsonage-road, Withington, Manchester.
1861. *Chapman, Edward, M.A., M.P., F.L.S., F.C.S. Hill End, Mottram, Manchester.
1897. ‡Chapman, Edward Henry. 17 St. Hilda's-terrace, Whitby.
1889. ‡Chapman, L. H. 147 Park-road, Newcastle-upon-Tyne.
1884. ‡Chapman, Professor. University College, Toronto, Canada.
1899. §Chapman, Professor Sydney John, M.A. The Owens College, Manchester.
1877. ‡Chapman, T. Algernon, M.D. 17 Wesley-avenue, Liscard, Cheshire.
1874. ‡Charles, J. J., M.D., Professor of Anatomy and Physiology in Queen's College, Cork. Newmarket, Co. Cork.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1903. §Chaster, G. W., M.D. 42 Talbot-road, Southport.
1886. ‡Chate, Robert W. Southfield, Edgbaston, Birmingham.
1884. *Chatterton, George, M.A., M.Inst.C.E. 6 The Sanctuary, Westminster, S.W.
1886. *Chattock, A. P., M.A., Professor of Experimental Physics in University College, Bristol.
1867. *Chatwood, Samuel, F.R.G.S. High Lawn, Broad Oak Park, Worsley, Manchester.
1904. *Chaundy, Theodore William. 40 Broad-street, Oxford.
1884. ‡Chauveau, The Hon. Dr. Montreal, Canada.
1883. ‡Chawner, W., M.A. Emmanuel College, Cambridge.
1864. ‡Cheadle, W. B., M.A., M.D., F.R.G.S. 19 Portman-street, Portman-square, W.
1900. §Cheesman, W. Norwood. The Crescent, Selby.
1887. ‡*Cheetham, F. W. Limefield House, Hyde.*
1887. ‡*Cheetham, John. Limefield House, Hyde.*
1896. ‡Chenie, John. Charlotte-street, Edinburgh.
1874. *Chermside, Major-General Sir H. C., R.E., G.C.M.G., C.B. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, S.W.
1884. ‡*Cherriman, Professor J. B. Ottawa, Canada.*
1896. ‡Cherry, R. B. 92 Stephen's-green, Dublin.
1879. *Chesterman, W. Belmayne, Sheffield.
1883. ‡Chinery, Edward F. Monmouth House, Lymington.
1884. ‡Chipman, W. W. L. 957 Dorchester-street, Montreal, Canada.
1889. ‡Chirney, J. W. Morpeth.
1894. ‡Chisholm, G. G., M.A., B.Sc., F.R.G.S. 59 Drakefield-road, Upper Tooting, S.W.
1900. ‡Chisholm, Sir Samuel. Glasgow.
1899. §Chitty, Edward. Sonnenberg, Castle Avenue, Dover.
1899. §Chitty, Mrs. Edward. Sonnenberg, Castle Avenue, Dover.
1899. §Chitty, G. W. Mildura, Park-avenue, Dover.
1882. ‡Chorley, George. Midhurst, Sussex.

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Year of Election.

1887. †*Chorlton, J. Clayton. New Holme, Withington, Manchester.*
1893. *Chree, Charles, D.Sc., F.R.S. Kew Observatory, Richmond, Surrey.
1900. *Christie, R. J. Duke Street, Toronto, Canada.
1875. *Christopher, George, F.C.S. May Villa, Lucien-road, Tooting Common, S.W.
1876. *Chrystal, George, M.A., LL.D., F.R.S.E. (Pres. A, 1885), Professor of Mathematics in the University of Edinburgh. 5 Belgrave-crescent, Edinburgh.
1870. §Church, A. H., M.A., F.R.S., F.S.A., Professor of Chemistry in the Royal Academy of Arts. Shelsley, Ennerdale-road, Kew.
1898. §Church, Colonel G. Earl, F.R.G.S. (Pres. E, 1898). 216 Cromwell-road, S.W.
1860. †Church, Sir William Selby, Bart., M.D. St. Bartholomew's Hospital, E.C.
1896. †Clague, Daniel, F.G.S. 5 Sandstone-road, Stoneycroft, Liverpool.
1903. §Clapham, J. H. Yorkshire College, Leeds.
1901. §Clark, Archibald B., M.A. 16 Comely Bank-street, Edinburgh.
1876. †Clark, David R., M.A. 8 Park-drive West, Glasgow.
1890. †Clark, E. K. 13 Wellclose-place, Leeds.
1877. *Clark, F. J., J.P., F.L.S. Netherleigh, Street, Somerset.
1902. †Clark, G. M. Cape Town.
1892. †Clark, James. Chapel House, Paisley.
1901. †Clark, James M., M.A., B.Sc. 8 Park-drive West, Glasgow.
1876. †Clark, Dr. John. 138 Bath-street, Glasgow.
1881. †Clark, J. Edmund, B.A., B.Sc. 112 Wool Exchange, E.C.
1901. *Clark, Robert M., B.Sc., F.L.S. 27 Albyn-place, Aberdeen.
1855. †Clark, Rev. William, M.A. Beechcroft, Jordan-hill, Glasgow.
1887. §Clarke, C. Goddard, J.P. South Lodge, Champion Hill, S.E.
1875. †Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
1886. †Clarke, David. Langley-road, Small Heath, Birmingham.
1875. †Clarke, John Henry (Local Sec. 1875). 4 Worcester-terrace, Clifton, Bristol.
1902. §Clarke, Miss Lilian J., B.Sc. 81 Hornsey Rise, N.
1897. †*Clarke, Colonel S. C., R.E. Parklands, Caversham, near Reading.*
1896. †Clarke, W. W. Albert Dock Office, Liverpool.
1884. †Claxton, T. James. 461 St. Urbain-street, Montreal, Canada.
1889. *Clayden, A. W., M.A., F.G.S. St. John's, Polsloe-road, Exeter.
1890. *Clayton, William Wikely. Gipton Lodge, Leeds.
1861. †Cleland, John, M.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 2 The University, Glasgow.
1902. §Clements, Olaf P. Tana, St. Bernard's-road, Olton, Warwick.
1861. *Clifton, R. Bellamy, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 8 Bardwell-road, Banbury-road, Oxford.
1898. †Clissold, H. 30 College-road, Clifton, Bristol.
1893. †Clofford, William. 36 Mansfield-road, Nottingham.
Clonbrock, Lord Robert. Clonbrock, Galway.
1873. †Clough, John. Bracken Bank, Keighley, Yorkshire.
1892. †Clouston, T. S., M.D. Tipperlinn House, Edinburgh.
1883. *Clowes, Frank, D.Sc., F.C.S. (Local Sec. 1893). The Grange, College-road, Dulwich, S.E.
1885. †Clyne, James. Rubislaw Den South, Aberdeen.
1891. *Coates, Henry. Pitcullen House, Perth.
1897. †Coates, J., M.Inst.C.E. 99 Queen-street, Melbourne, Australia.
1903. *Coates, W. M. King's College, Cambridge.
1901. †Coats, Allan. Hayfield, Paisley.
1884. §Cobb, John. Fitzherries, Abingdon.

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Year of Election.

1895. *Cobbold, Felix T., M.A. The Lodge, Felixstowe, Suffolk.
1889. ‡Cochrane, Cecil A. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1864. *Cochrane, James Henry. Burston House, Pittville, Cheltenham.
1889. ‡Cochrane, William. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1892. ‡*Cockburn, John. Glencorse House, Milton Bridge, Edinburgh.*
1901. ‡Cockburn, Sir John, K.C.M.G., M.D. 10 Gatestone-road, Upper Norwood, S.E.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G.S. Whinsbridge, Grosvenor-road, Bournemouth.
1898. ‡Coffey, George. 5 Harcourt-terrace, Dublin.
1881. *Coffin, Walter Harris, F.C.S. 26 Belgrave-road, Eccleston-square, S.W.
1896. *Coghill, Percy de G. 4 Sunnyside, Prince's Park, Liverpool.
1884. *Cohen, B. L., M.P. 30 Hyde Park-gardens, W.
1887. ‡Cohen, Julius B. Yorkshire College, Leeds.
1901. §Cohen, N. L. 11 Hyde Park-terrace, W.
1901. *Cohen, R. Waley. 11 Hyde Park-terrace, W.
1894. *Colby, Miss E. L., B.A. Carregwen, Aberystwyth.
1895. *Colby, James George Ernest, M.A., F.R.C.S. Malton, Yorkshire.
1895. *Colby William Henry. Carregwen, Aberystwyth.
1893. ‡Cole, Professor Grenville A. J., F.G.S. Royal College of Science, Dublin.
1903. §Cole, Otto B. 551 Boylston-street, Boston, U.S.A.
1879. ‡Cole, Skelton. 387 Glossop-road, Sheffield.
1864. ‡Colefax, H. Arthur, Ph.D., F.C.S. 14 Chester-terrace, Chester-square, S.W.
1897. §Coleman, Dr. A. P. 476 Huron-street, Toronto, Canada.
1893. ‡Coleman, J. B., F.C.S., A.R.C.S. University College, Nottingham.
1899. §Coleman, William. The Shrubbery, Buckland, Dover.
1878. ‡Coles, John, F.R.G.S. Liphook, Hants.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1899. §Collard, George. The Gables, Canterbury.
1892. ‡Collet, Miss Clara E. 7 Coleridge-road, N.
1892. ‡Collie, Alexander. Harlaw House, Inverurie.
1887. ‡Collie, J. Norman, Ph.D., F.R.S., Professor of Organic Chemistry in the University of London. 16 Campden-grove, W.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1893. ‡Collinge, Walter E. The University, Birmingham.
1861. *Collingwood, J. Frederick, F.G.S. 5 Irene-road, Parson's Green, S.W.
1876. ‡Collins, J. H., F.G.S. 162 Barry-road, S.E.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1902. ‡Collins, T. R. Belfast Royal Academy, Belfast.
1882. ‡Colmer, Joseph G., C.M.G. Office of the High Commissioner for Canada, 17 Victoria-street, S.W.
1884. ‡Colomb, Right Hon. Sir J. C. R., K.C.M.G., M.P., F.R.G.S. Dromquinna, Kenmare, Kerry, Ireland; and Junior United Service Club, S.W.
1897. ‡Colquhoun, A. H. U., B.A. 39 Borden-street, Toronto, Canada.
1888. †Commans, R. D. Macaulay-buildings, Bath.
1891. ‡*Common, J. F. F.* 21 *Park-place, Cardiff.*
1900. ‡Common, T. A., B.A. 63 Eaton-rise, Ealing, W.
1892. ‡Comyns, Frank, M.A., F.C.S. The Grammar School, Durham.
1884. ‡Conklin, Dr. William A. Central Park, New York, U.S.A.
1896. ‡Connacher, W. S. Birkenhead Institute, Birkenhead.
1890. ‡Connon, J. W. Park-row, Leeds.

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Year of election.

1871. *Connor, Charles C. 4 Queen's Elms, Belfast.
1902. ‡Conway, A. W. 100 Leinster-road, Rathmines, Dublin.
1893. ‡Conway, Professor Sir W. M., M.A., F.R.G.S. The Red House, Hornton-street, W.
1903. §Conway, R. Seymour, Litt.D., Professor of Latin in Owens College, Manchester.
1899. ‡Coode, J. Charles, M.Inst.C.E. Westminster-chambers, 9 Victoria-street, S.W.
1898. §Cook, Ernest H. 27 Berkeley-square, Clifton, Bristol.
1900. ‡Cook, Walter. 98 St. Mary's-street, Cardiff.
1882. ‡Cooke, Major-General A. C., R.E., C.B., F.R.G.S. Palace-chambers, Ryder-street, S.W.
1876. *Cooke, Conrad W. 28 Victoria-street, S.W.
1881. ‡Cooke, F. Bishopshill, York.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
1868. ‡Cooke, M. C., M.A. 53 Castle-road, Kentish Town, N.W.
1884. ‡Cooke, R. P. Brockville, Ontario, Canada.
1881. ‡Cooke, Thomas. Bishopshill, York.
1896. ‡Cookson, E. H. Kiln Hey, West Derby.
1899 *Coomáraswámy, A. K., B.Sc., F.L.S., F.G.S., Director of the Mineral Survey of Ceylon. Kandy, Ceylon.
1902. *Coomáraswámy, Mrs. A. K. Kandy, Ceylon.
1903. §Cooper, Miss A. J. 22 St. John-street, Oxford.
1895. ‡Cooper, Charles Friend, M.I.E.E. 68 Victoria-street, Westminster, S.W.
1901. *Cooper, C. Forster, B.A. Trinity College, Cambridge.
1893. ‡Cooper, F. W. 14 Hamilton-road, Sherwood Rise, Nottingham.
1868. ‡Cooper, W. J. New Malden, Surrey.
1889. ‡Coote, Arthur. The Minories, Jesmond, Newcastle-upon-Tyne.
1878. ‡Cope, Rev. S. W. Bramley, Leeds.
1871. ‡Copeland, Ralph, Ph.D., F.R.A.S., Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh.
1881. ‡Copperthwaite, H. Holgate Villa, Holgate-lane, York.
1901. §Corbett, A. Cameron, M.P. Thornliebank House, Glasgow.
1891. ‡Corbett, E. W. M. Y Fron, Pwllypant, Cardiff.
1887. *Corcoran, Bryan. Fairlight, 22 Oliver-grove, South Norwood, S.E.
1894. §Corcoran, Miss Jessie R. The Chestnuts, Mulgrave-road, Sutton, Surrey.
1883. *Core, Professor Thomas H., M.A. Fallowfield, Manchester.
1901. *Cormack, Professor J. D., B.Sc. University College, Gower-street, W.C.
1893. *Corner, Samuel, B.A., B.Sc. 95 Forest-road West, Nottingham.
1889. ‡Cornish, Vaughan, D.Sc., F.R.G.S. 72 Prince's-square, W.
1884. *Cornwallis, F. S. W., M.P., F.L.S. Linton Park, Maidstone.
1885. ‡Corry, John. Rosenheim, Park Hill-road, Croydon.
1888. ‡Corser, Rev. Richard K. 57 Park Hill-road, Croydon.
1900. §Cortie, Rev. A. L., F.R.A.S. Stonyhurst College, Blackburn.
1891. ‡Cory, John, J.P. Vaindre Hall, near Cardiff.
1891. ‡Cory, Alderman Richard, J.P. Oscar House, Newport-road, Cardiff.
1891. **Cotsworth, Haldane Gwilt. The Cedars, Cobham-road, Norbiton, S.W.*
1874. *Cotterill, J. H., M.A., F.R.S. Braeside, Speldhurst, Kent.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1896. ‡Courtney, Right Hon. Leonard (Pres. F, 1896). 15 Cheyne-walk, Chelsea, S.W.
1890. ‡Cousins, John James. Allerton Park, Chapel Allerton, Leeds.

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Year of Election.

1896. ‡Coventry, J. 19 Sweeting-street, Liverpool.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1883. ‡Cowan, John A. Blaydon Burn, Durham.
1872. *Cowan, Thomas William, F.L.S., F.G.S. 10 Buckingham-street, Strand, W.C.
1903. §Coward, H. Knowle Board School, Bristol.
1900. §Cowburn, Henry. Dingle Head, Westleigh, Leigh, Lancashire.
1895. *Cowell, Philip H., M.A. Royal Observatory, Greenwich, and 74 Vanbrugh-park, Blackheath, S.E.
1899. §Cowper-Coles, Sherard. 82 Victoria-street, S.W.
1867. *Cox, Edward. Cardean, Meigle, N.B.
1892. ‡Cox, Robert. 34 Drumsheugh-gardens, Edinburgh.
1882. ‡Cox, Thomas A., District Engineer of the S., P., and D. Railway, Lahore, Punjab. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1888. ‡Cox, Thomas W. B. The Chestnuts, Lansdowne, Bath.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1890. ‡Cradock, George. Wakefield.
1892. *Craig, George A. Post Office, Mooroopna, Victoria, Australia.
1902. ‡Craig, H. C. Strandtown, Belfast.
1884. §Craigie, Major P. G., C.B., F.S.S. (Pres. F, 1900). 6 Lyndhurst-road, Hampstead, N.W.
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1884. ‡Crathern, James. Sherbrooke-street, Montreal, Canada.
1887. ‡*Craven, John. Smedley Lodge, Cheetham, Manchester.*
1887. *Craven, Thomas, J.P. Woodheyes Park, Ashton-upon-Mersey.
1871. *Crawford and Balcarres, The Right Hon. the Earl of, K.T., LL.D., F.R.S., F.R.A.S. 2 Cavendish-square, W.; and Haigh Hall, Wigan.
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Colinton-road, Edinburgh.
1846. *Crawshaw, The Right Hon. Lord. Whatton, Loughborough.
1890. §Crawshaw, Charles B. Rufford Lodge, Dewsbury.
1883. *Crawshaw, Edward, F.R.G.S. 25 Tollington-park, N.
1870. *Crawshay, Mrs. Robert. Caversham Park, Reading.
1885. §Creak, Captain E. W., C.B, R.N., F.R.S. (Pres. E., 1903; Council 1896–1903). 9 Hervey-road, Blackheath, S.E.
1901. ‡Cree, T. S. 15 Montgomerie-quadrant, Glasgow.
1896. ‡Cregeen, A. C. 21 Prince's-avenue, Liverpool.
1879. ‡Creswick, Nathaniel. Chantry Grange, near Sheffield.
1876. *Crewdson, Rev. Canon George. St. Mary's Vicarage, Windermere.
1887. *Crewdson, Theodore. Norcliffe Hall, Handforth, Manchester.
1896. ‡Crichton, Hugh. 6 Rockfield-road, Anfield, Liverpool.
1880. *Crisp, Frank, B.A., LL.B., F.L.S., F.G.S. 5 Lansdowne-road, Notting Hill, W.
1890. *Croft, W. B., M.A. Winchester College, Hampshire.
1878. ‡Croke, John O'Byrne, M.A. Clouneagh, Ballingarry-Lacy, Co. Limerick.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1885. ‡Crombie, J. W., M.A., M.P. (Local Sec. 1885). Balgownie Lodge, Aberdeen.
1885. ‡Crombie, Theodore. 18 Albyn-place, Aberdeen.
1903. §Crompton, Holland. Glynn Cottage, Northwood, Middlesex.
1901. ‡Crompton, Colonel R. E., C.B., M.Inst.C.E. (Pres. G, 1901). Kensington Court, W.
1887. ‡Crook, Henry T., M.Inst.C.E. 9 Albert-square, Manchester.
1898. §Crooke, William. Langton House, Charlton Kings, Cheltenham.

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Year of Election.

1865. §Crookes, Sir William, F.R.S., V.P.C.S. (President, 1898; Pres. B, 1886; Council 1885–91). 7 Kensington Park-gardens, W.
1879. ‡Crookes, Lady. 7 Kensington Park-gardens, W.
1897. *Crookshank, E. M., M.B. Ashdown Forest, Forest Row, Sussex.
1870. ‡Crosfield, C. J. Gledhill, Sefton Park, Liverpool.
1894. *Crosfield, Miss Margaret C. Undercroft, Reigate.
1870. *Crosfield, William. 3 Fulwood-park, Liverpool.
1890. ‡Cross, E. Richard, LL.B. Harwood House, New Parks-crescent, Scarborough.
1853. ‡Crosskill, William. Beverley, Yorkshire.
1887. *Crossley, William J. Glenfield, Bowdon, Cheshire.
1894. *Crosweller, William Thomas, F.Z.S., F.I.Inst. Kent Lodge, Sidcup, Kent.
1897. *Crosweller, Mrs. W. T. Kent Lodge, Sidcup, Kent.
1883. ‡Crowder, Robert. Stanwix, Carlisle.
1882. §Crowley, Frederick. Ashdell, Alton, Hampshire.
1890. *Crowley, Ralph Henry, M.D. 116 Manningham-lane, Bradford.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-upon-Tyne.
1885. ‡Cruickshank, Alexander, LL.D. 20 Rose-street, Aberdeen.
1888. ‡Crummack, William J. London and Brazilian Bank, Rio de Janeiro, Brazil.
1898. ‡Crundall, Sir William H. Dover.
1888. ‡Culley, Robert. Bank of Ireland, Dublin.
1883. *Culverwell, Edward P., M.A. 40 Trinity College, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1897. ‡Cumberland, Barlow. Toronto, Canada.
1898. §Cundall, J. Tudor. 1 Dean Park-crescent, Edinburgh.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1882. *Cunningham, Lieut.-Colonel Allan, R.E., A.I.C.E. 20 Essex-villas, Kensington, W.
1877. *Cunningham, D. J., M.D., D.C.L., F.R.S., F.R.S.E. (Pres. H, 1901; Council, 1902–), Professor of Anatomy in the University of Edinburgh.
1891. ‡Cunningham, J. H. 2 Ravelston-place, Edinburgh.
1885. ‡Cunningham, J. T., B.A. Biological Laboratory, Plymouth.
1869. ‡Cunningham, Robert O., M.D., F.L.S., F.G.S., Professor of Natural History in Queen's College, Belfast.
1883. *Cunningham, Rev. W., D.D., D.Sc. (Pres. F, 1891). Trinity College, Cambridge.
1892. §Cunningham-Craig, E. H., B.A., F.G.S. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1900. *Cunnington, W. Alfred. 13 The Chase, Clapham Common, S.W.
1892. *Currie, James, jun., M.A., F.R.S.E. Larkfield, Golden Acre, Edinburgh.
1884. ‡Currier, John McNab. Newport, Vermont, U.S.A.
1902. §Curry, Professor M., M.Inst.C.E. Mostyn Dale, 3 Mostyn-road, Merton Park, Wimbledon.
1898. ‡Curtis, John. 1 Christchurch-road, Clifton, Bristol.
1878. ‡Curtis, William. Caramore, Sutton, Co. Dublin.
1884. ‡Cushing, Frank Hamilton. Washington, U.S.A.
1883. ‡Cushing, Mrs. M. Croydon, Surrey.
1881. §Cushing, Thomas, F.R.A.S. India Store Depôt, Belvedere-road, Lambeth, S.W.

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Year of Election.

1854. ‡Daglish, Robert. Orrell Cottage, near Wigan.
1883. ‡Dähne, F. W., Consul of the German Empire. 18 Somerset-place, Swansea.
1898. §Dalby, Professor W. E., D.Sc., M.Inst.C.E. 45 Clifton-road, Crouch End, N.
1889. *Dale, Miss Elizabeth. 45 Oxford-road, Cambridge.
1863. ‡Dale, J. B. South Shields.
1867. ‡Dalgleish, W. Dundee.
1870. ‡Dallinger, Rev. W. H., D.D., LL.D., F.R.S., F.L.S. Ingleside, Newstead-road, Lee, S.E.
Dalton, Edward, LL.D. Dunkirk House, Nailsworth.
1862. ‡Danby, T. W., M.A., F.G.S. The Crouch, Seaford, Sussex.
1901. ‡Daniell, G. F., B.Sc. 44 Cavendish-road, Brondesbury, N.W.
1876. *Dansken, John, F.R.A.S. 2 Hillside-gardens, Partickhill, Glasgow.
1896. §Danson, F. C. Liverpool and London Chambers, Dale-street, Liverpool.
1849. *Danson, Joseph, F.C.S. Montreal, Canada.
1894. ‡Darbishire, B. V., M.A., F.R.G.S. 1 Savile-row, W.
1897. ‡Darbishire, C. W. Elm Lodge, Elm-row, Hampstead, N.W.
1897. §Darbishire, F. V., B.A., Ph.D. Hulme Hall, Plymouth-grove, and Owens College, Manchester.
1903. §Darbishire, Dr. Otto V. Owens College, Manchester.
1861. *Darbishire, Robert Dukinfield, B.A. (Local Sec. 1861). Victoria Park, Manchester.
1896. ‡Darbishire, W. A. Penybryn, Carnarvon, North Wales.
1899. *Darwin, Erasmus. The Orchard, Huntingdon-road, Cambridge.
1882. ‡Darwin, Francis, M.A., M.B., F.R.S., F.L.S. (Pres. D, 1891: Council 1882–84, 1897–1901). Wychfield, Huntingdon-road, Cambridge.
1881. *Darwin, George Howard, M.A., LL.D., F.R.S., F.R.A.S. (Pres. A, 1886; Council 1886–92), Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.
1878. *Darwin, Horace, M.A., F.R.S. The Orchard, Huntingdon-road, Cambridge.
1894. *Darwin, Major Leonard, Hon. Sec. R.G.S. (Pres. E, 1896; Council 1899–). 12 Egerton-place, South Kensington, S.W.
1882. ‡Darwin, W. E., M.A., F.G.S. Bassett, Southampton.
1880. *Davey, Henry, M.Inst.C.E., F.G.S. 3 Prince's-street, Westminster, S.W.
1898. §Davey, William John. 6 Water-street, Liverpool.
1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, E.C.
1870. ‡Davidson, Alexander, M.D. 2 Gambier-terrace, Liverpool.
1902. *Davidson, S. C. Seacourt, Bangor, Co. Down.
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1887. *Davies, H. Rees. Treborth, Bangor, North Wales.
1896. *Davies, Thomas Wilberforce, F.G.S. 41 Park-place, Cardiff.
1893. *Davies, Rev. T. Witton, B.A., Ph.D., Professor of Semitic Languages in University College, Bangor, North Wales.
1898. ‡Davies, Wm. Howell, J.P. Down House, Stoke Bishop, Bristol.
1873. *Davis, Alfred. 37 Ladbroke-grove, W.
1870. *Davis, A. S. St. George's School, Roundhay, near Leeds.
1882. ‡Davis, Henry C. Berry Pomeroy, Springfield-road, Brighton.
1896. *Davis, John Henry Grant. Valindra, Wood Green, Wednesbury, Staffordshire.
1885. *Davis, Rev. Rudolf. Hopefield, Evesham.
1886. ‡Davis, W. H. Hazeldean, Pershore-road, Birmingham.

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1886. ‡Davison, Charles, D.Sc. 16 Manor-road, Birmingham.
1857. ‡Davy, E. W., M.D. Kimmage Lodge, Roundtown, Dublin.
1869. ‡Daw, John. Mount Radford, Exeter.
1869. ‡Daw, R. R. M. Bedford-circus, Exeter.
1860. *Dawes, John T. The Lilacs, Prestatyn, North Wales.
1864. ‡Dawkins, W. Boyd, D.Sc., F.R.S., F.S.A., F.G.S. (Pres. C, 1888; Council, 1882–88), Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester. Woodhurst, Fallowfield, Manchester.
1886. ‡Dawson, Bernard. The Laurels, Malvern Link.
1891. ‡Dawson, Edward. 2 Windsor-place, Cardiff.
1885. **Dawson, Lieut.-Colonel H. P., R.A. Hartlington, Burnsall, Skipton.*
1901. *Dawson, P. The Acre, Maryhill, Glasgow.
1884. ‡Dawson, Samuel (Local Sec. 1884). 258 University-street, Montreal, Canada.
1859. **Dawson, Captain William G. The Links, Plumstead Common, Kent.*
1892. ‡Day, T. C., F.C.S. 36 Hillside-crescent, Edinburgh.
1870. *Deacon, G. F., M.Inst.C.E. (Pres. G, 1897). 19 Warwick-square, S.W.
1900. §Deacon, M. Whittington House, near Chesterfield.
1887. ‡Deakin, H. T. Egremont House, Belmont, near Bolton.
1861. ‡Dean, Henry. Colne, Lancashire.
1901. *Deasy, Capt. H. H. P. Cavalry Club, Piccadilly, W.
1884. *Debenham, Frank, F.S.S. 1 Fitzjohn's-avenue, N.W.
1866. ‡Debus, Heinrich, Ph.D., F.R.S., F.C.S. (Pres. B, 1869; Council, 1870–75). 4 Schlangenweg, Cassel, Hessen.
1884. ‡Deck, Arthur, F.C.S. 9 King's-parade, Cambridge.
1893. ‡Deeley, R. M. 38 Charnwood-street, Derby.
1878. ‡Delany, Rev. William. University College, Dublin.
1896. §Dempster, John. Tynron, Noctorum, Birkenhead.
1902. ‡Dendy, Professor Arthur. Care of Messrs. Dulau & Co., 37 Soho-square, W.
1897. ‡Denison, F. Napier. Meteorological Office, Victoria, B.C., Canada.
1896. ‡Denison, Miss Louisa E. 16 Chesham-place, S.W.
1889. §Denny, Alfred, F.L.S., Professor of Biology in University College, Sheffield.
Dent, William Yerbury. 5 Caithness-road, Brook Green, W.
1874. ‡De Rance, Charles E., F.G.S. 33 Carshalton-road, Blackpool.
1896. ‡Derby, The Right Hon. the Earl of, K.G., G.C.B. Knowsley, Prescot, Lancashire.
1874. *Derham, Walter, M.A., LL.M., F.G.S. 76 Lancaster-gate, W.
1894. *Deverell, F. H. 7 Grote's-place, Blackheath, S.E.
1903. §Devereux, Rev. E. R. Price. Drachenfeld, Tenison-avenue, Cambridge.
1899. ‡Devonshire, The Duke of, K.G., D.C.L., F.R.S. (Vice-President, 1904.) 78 Piccadilly, W.
1899. ‡Dewar, A. Redcote. Redcote, Leven, Fife.
1868. *Dewar, James, M.A., LL.D., F.R.S., F.R.S.E., V.P.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge (President, 1902; Pres. B, 1879; Council 1883–88). 1 Scroope-terrace, Cambridge.
1881. ‡Dewar, Mrs. 1 Scroope-terrace, Cambridge.
1883. ‡Dewar, James, M.D., F.R.C.S.E. Drylaw House, Davidson's Mains, Midlothian, N.B.

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1884. *Dewar, William, M.A. Horton House, Rugby.
1872. ‡Dewick, Rev. E. S., M.A., F.G.S. 26 Oxford-square, W.
1884. ‡De Wolf, O. C., M.D. Chicago, U.S.A.
1896. ‡D'Hemry, P. 136 Prince's-road, Liverpool.
1897. ‡Dick, D. B. Toronto, Canada.
1901. §Dick, George Handasyde. 31 Hamilton-drive, Hillhead, Glasgow.
1901. ‡Dick, Thomas. Lochhead House, Pollokshields, Glasgow.
1889. ‡Dickinson, A. H. The Wood, Maybury, Surrey.
1863. ‡Dickinson, G. T. Lily-avenue, Jesmond, Newcastle-upon-Tyne.
1887. ‡Dickinson, Joseph, F.G.S. South Bank, Pendleton.
1884. ‡Dickson, Charles R., M.D. Wolfe Island, Ontario, Canada.
1881. ‡Dickson, Edmund, M.A., F.G.S. 2 Starkie-street, Preston.
1887. §Dickson, H. N., B.Sc., F.R.S.E., F.R.G.S. 2 St. Margaret's-road, Oxford.
1902. §Dickson, James D. Hamilton, M.A., F.R.S.E. 6 Cranmer-road, Cambridge.
1885. ‡Dickson, Patrick. Laurencekirk, Aberdeen.
1862. *Dilke, The Right Hon. Sir Charles Wentworth, Bart., M.P., F.R.G.S. 76 Sloane-street, S.W.
1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.
1901. §Dines, W. H. Oxshott, Leatherhead
1900. §Divers, Dr. Edward, F.R.S. (Pres. B, 1902). 3 Canning-place, Palace Gate, W.
1898. *Dix, John William S. Hampton Lodge, Durdham Down, Clifton, Bristol.
1899 *Dixon, A. C., D.Sc., Professor of Mathematics in Queen's College, Belfast. Almora, Myrtlefield Park, Belfast.
1874. *Dixon, A. E., M.D., Professor of Chemistry in Queen's College, Cork. Mentone Villa, Sunday's Well, Cork.
1900. §Dixon, A. Francis, D.Sc., Professor of Anatomy in University College, Cardiff.
1883. ‡Dixon, Miss E. 2 Cliff-terrace, Kendal.
1888. §Dixon, Edward T. Racketts, Hythe, Hampshire.
1900. *Dixon, George, M.A. St. Bees, Cumberland.
1879. *Dixon, Harold B., M.A., F.R.S., F.C.S. (Pres. B, 1894), Professor of Chemistry in the Owens College, Manchester.
1902. ‡Dixon, Henry H., D.Sc. 23 Northbrook-road, Dublin.
1885. ‡Dixon, John Henry. Dundarach, Pitlochry, N.B.
1896. §Dixon-Nuttall, F. R. Ingleholme, Eccleston Park, Prescot.
1887. ‡Dixon, Thomas. Buttershaw, near Bradford, Yorkshire.
1902. ‡Dixon, W. V. Scotch Quarter, Carrickfergus.
1885. ‡Doak, Rev. A. 15 Queen's-road, Aberdeen.
1890. ‡Dobbie, James J., D.Sc., Director of the Museum of Science and Art, Edinburgh.
1885. §Dobbin, Leonard, Ph.D. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. Hartley Manor, Longfield, Kent.
1902. ‡Dobbs, F. W. 2 Willowbrook, Eton, Windsor.
1897. ‡Doberck, William. The Observatory, Hong Kong.
1892. ‡Dobie, W. Fraser. 47 Grange-road, Edinburgh.
1891. ‡Dobson, G. Alkali and Ammonia Works, Cardiff.
1875. *Docwra, George. Cinderford, R.S.O., Gloucestershire.
1870. *Dodd, John. Nunthorpe-avenue, York.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1897. ‡Dodge, Richard E. Teachers' College, Columbia University, New York, U.S.A.
1889. ‡Dodson, George, B.A. Downing College, Cambridge.

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1898. ‡Dole, James. Redland House, Bristol.
1893. ‡Donald, Charles W. Kinsgarth, Braid-road, Edinburgh.
1885. ‡Donaldson, James, M.A., LL.D., F.R.S.E., Senior Principal of the University of St. Andrews, N.B.
1889. ‡Donkin, R. S., M.P. Campville, North Shields.
1896. ‡Donnan, F. E. Ardenmore-terrace, Holywood, Ireland.
1901. ‡Donnan, F. G. University College, Gower Street, W.C.
1881. ‡Dorrington, John Edward. Lypiatt Park, Stroud.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1863. *Doughty, Charles Montagu. Illawara House, Tunbridge Wells.
1884. ‡Douglass, William Alexander. Freehold Loan and Savings Company, Church-street, Toronto, Canada.
1890. ‡Dovaston, John. West Felton, Oswestry.
1883. ‡Dove, Arthur. Crown Cottage, York.
1884. ‡Dove, Miss Frances. St. Leonard's, St. Andrews, N.B.
1903. §Dow, Miss Agnes R. Flat 1, 27 Warrington-crescent, W.
1876. ‡Dowie, Mrs. Muir. Golland, by Kinross, N.B.
1884. *Dowling, D. J. Bromley, Kent.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, J. Emerson, M.Inst.C.E. Merry Hall, Ashtead, Surrey.
1887. ‡Doxey, R. A. Slade House, Levenshulme, Manchester.
1894. ‡Doyne, R. W., F.R.C.S. 28 Beaumont-street, Oxford.
1883. ‡Draper, William. De Grey House, St. Leonard's, York.
1892. *Dreghorn, David, J.P. Greenwood, Pollokshields, Glasgow.
1868. ‡Dresser, Henry E., F.Z.S. 110 Cannon-street, E.C.
1890. ‡Drew, John. 12 Harringay-park, Crouch End, Middlesex, N.
1892. ‡Dreyer, John L. E., M.A., Ph.D., F.R.A.S. The Observatory, Armagh.
1893. §Druce, G. Claridge, M.A., F.L.S. (Local Sec. 1894). 118 High-street, Oxford.
1889. ‡Drummond, Dr. 6 Saville-place, Newcastle-upon-Tyne.
1897. ‡Drynan, Miss. Northwold, Queen's Park, Toronto, Canada.
1901. ‡Drysdale, John W. W. Bon Accord Engine Works, London-road, Glasgow.
1892. ‡Du Bois, Dr. H. Mittelstrasse, 39, Berlin.
1856. *Ducie, The Right. Hon. Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, W.; and Tortworth Court, Falfield, Gloucestershire.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. Christchurch Vicarage, Chester.
1900. *Duckworth, W. L. H. Jesus College, Cambridge.
1895. *Duddell, William. 47 Hans-place, S.W.
1867. *Duff, The Right Hon. Sir Mountstuart Elphinstone Grant-, G.C.S.I., F.R.S., F.R.G.S. (Pres. F, 1867, 1881; Council 1868, 1892-93). 11 Chelsea-embankment, S.W.
1875. ‡Duffin, W. E. L'Estrange. Waterford.
1890. ‡Dufton, S. F. Trinity College, Cambridge.
1884. ‡Dugdale, James H. 9 Hyde Park-gardens, W.
1883. ‡Duke, Frederic. Conservative Club, Hastings.
1892. ‡Dulier, Colonel E., C.B. 27 Sloane-gardens, S.W.
1891. *Duncan, John, J.P. 'South Wales Daily News' Office, Cardiff.
1896. ‡Duncanson, Thomas. 16 Deane-road, Liverpool.
1893. *Dunell, George Robert. 33 Spencer-road, Grove Park, Chiswick, W.
1892. ‡Dunham, Miss Helen Bliss. Messrs. Morton, Rose, & Co., Bartholomew House, E.C.
1896. *Dunkerley, S., M.Sc., Professor of Applied Mechanics in the Royal Naval College, Greenwich, S.E.

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1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1882. ‡*Dunn, J. T., M.Sc., F.C.S. Northern Polytecknic Institute, Holloway, N.*
1883. ‡*Dunn, Mrs. J. T. Northern Polytechnic Institute, Holloway, N.*
1876. ‡Dunnachie, James. 2 West Regent-street, Glasgow.
1884. §Dunnington, Professor F. P. University of Virginia, Charlottesville, Virginia, U.S.A.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1893. *Dunstan, M. J. R., Principal of the South-Eastern Agricultural College, Wye, Kent.
1891. ‡Dunstan, Mrs. South-Eastern Agricultural College, Wye, Kent.
1885. *Dunstan, Wyndham R., M.A., F.R.S., Sec.C.S., Director of the Imperial Institute, S.W.
1869. ‡D'Urban, W. S. M. Newport House, near Exeter.
1898. ‡Durrant, R. G. Marlborough College, Wilts.
1895. *Dwerryhouse, Arthur R., M.Sc., F.G.S. 5 Oakfield-terrace, Headingley, Leeds.
1884. ‡Dyck, Professor Walter. The University, Munich.
1885. *Dyer, Henry, M.A., D.Sc. 8 Highburgh-terrace, Dowanhill, Glasgow.
1869. *Dymond, Edward E. Oaklands, Aspley Guise, Bletchley.
1895. §Dymond, Thomas S., F.C.S. County Technical Laboratory, Chelmsford, Essex.

1868. ‡Eade, Sir Peter, M.D. Upper St. Giles's-street, Norwich.
1895. ‡*Earle, Hardman A. 20 Queen Anne's-gate, Westminster, S.W.*
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
1874. ‡Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1899. §East, W. H. Municipal School of Art, Science, and Technolcgy, Dover.
1871. *Easton, Edward (Pres. G, 1878; Council 1879–81). 7 Victoria-street, Westminster, S.W.
1863. ‡Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John. Durie House, Abercromby-street, Helensburgh, N.B.
1883. ‡Eastwood, Miss. Littleover Grange, Derby.
1893. *Ebbs, Alfred B. Northumberland-alley, Fenchurch-street, E.C.
1903. §Eccles, W. H., D.Sc. 1 Owen's-mansions, Queen's Club-gardens, West Kensington, W.
1884. ‡Eckersley, W. T. Standish Hall, Wigan, Lancashire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1870. *Eddison, John Edwin, M.D., M.R.C.S. The Lodge, Adel, Leeds.
1899. ‡Eddowes, Alfred, M.D. 28 Wimpole-street, W.
*Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.
1887. ‡Ede, Francis J., F.G.S. Silchar, Cachar, India.
1884. *Edgell, Rev. R. Arnold, M.A., F.C.S. Sywell House, Llandudno.
1887. §Edgeworth, F. Y., M.A., D.C.L., F.S.S. (Pres. F, 1889; Council 1879–86, 1891–98), Professor of Political Economy in the University of Oxford. All Souls College, Oxford.
1870. *Edmonds, F. B. 6 Clement's Inn, W.C.
1883. ‡Edmonds, William. Wiscombe Park, Colyton, Devon.
1888. *Edmunds, Henry. Antron, 71 Upper Tulse-hill, S.W.
1884. *Edmunds, James, M.D. 4 Chichester-terrace, Kemp Town, Brighton.
1883. ‡Edmunds, Lewis, D.Sc., LL.M., F.G.S. 1 Garden-court, Temple, E.C.

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1901. *Edridge-Green, F. W., M.D., F.R.C.S. 14 Welbeck-street, W.
1899. §Edwards, E. J., Assoc.M.Inst.C.E. 2 Dafforne-road, Upper Tooting, S.W.
1903. §Edwards, Mrs. Emily. Norley Grange, 73 Leyland-road, Southport.
1903. §Edwards, Francis. Norley Grange, 73 Leyland-road, Southport.
1903. §Edwards, Miss Marion K. Norley Grange, 73 Leyland-road, Southport.
1884. †Edwards, W. F. Niles, Michigan, U.S.A.
1887. *Egerton of Tatton, The Right Hon. Lord. Tatton Park, Knutsford.
1901. †Eggar, W. D. Willowbrook, Eton, Windsor.
1896. †Ekkert, Miss Dorothea. 95 Upper Parliament-street, Liverpool.
1876. †Elder, Mrs. 6 Claremont-terrace, Glasgow.
1890. §Elford, Percy. St. John's College, Oxford.
1885. *Elgar, Francis, LL.D., F.R.S., F.R.S.E., M.Inst.C.E. 34 Leadenhall-street, E.C.
1901. *Elles, Miss Gertrude L. Newnham College, Cambridge.
1883. †Ellington, Edward Bayzand, M.Inst.C.E. Palace-chambers, Bridge-street, Westminster, S.W.
1891. †Elliott, A. C., D.Sc., Professor of Engineering in University College, Cardiff. 2 Plasturton-avenue, Cardiff.
1883. *Elliott, Edwin Bailey, M.A., F.R.S., F.R.A.S., Waynflete Professor of Pure Mathematics in the University of Oxford. 4 Bardwell-road, Oxford.
Elliott, John Fogg. Elvet Hill, Durham.
1886. †Elliot, Sir Thomas Henry, K.C.B., F.S.S. Board of Agriculture, 4 Whitehall-place, S.W.
1875. *Ellis, H. D. 12 Gloucester-terrace, Hyde Park, W.
1880. *Ellis, John Henry (Local Sec. 1883). Woodhaye, Ivy Bridge, Devon.
1891. §Ellis, Miss M. A. 129 Walton-street, Oxford.
1884. †Ellis, Professor W. Hodgson, M.A., M.B. 74 St. Alban's-street, Toronto, Canada.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1887. †Elmy, Ben. Congleton, Cheshire.
1862. †Elphinstone, Sir H. W., Bart., M.A., F.L.S. 2 Stone-buildings, Lincoln's Inn, W.C.
1899. *Elvery, Miss Amelia. The Cedars, Maison Dieu-road, Dover.
1897. §Elvery, Mrs. Elizabeth. The Cedars, Maison Dieu-road, Dover.
1883. †Elwes, Captain George Robert. Bossington, Bournemouth.
1887. §Elworthy, Frederick T., F.S.A. Foxdown, Wellington, Somerset.
1870. *Ely, The Right Rev. Lord Alwyne Compton, D.D., Lord Bishop of. (Vice-President, 1904.) The Palace, Ely, Cambridgeshire.
1897. †Ely, Robert E. 23 West 44th-street, New York, U.S.A.
1891. †Emerton, Wolseley, D C.I.. Banwell Castle, Somerset.
1884. †Emery, Albert H. Stamford, Connecticut, U.S.A.
1863. †Emery, The Ven. Archdeacon, B.D. Ely, Cambridgeshire.
1894. †Emtage, W. T. A., Director of Public Instruction, Mauritius.
1866. †Enfield, Richard. Low Pavement, Nottingham.
1884. †England, Luther M. Knowlton, Quebec, Canada.
1853. †English, E. Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1883. †Entwistle, James P. Beachfield, 2 Westcliffe-road, Southport.
1869. *Enys, John Davis. Enys, Penryn, Cornwall.
1894. §Erskine-Murray, James, D.Sc., F.R.S.E. University College, Nottingham.
1862. *Esson, William, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford. 13 Bradmore-road, Oxford.
1887. *Estcourt, Charles. 5 Seymour-grove, Old Trafford, Manchester.

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1887. *Estcourt, P. A., F.C.S., F.I.C. 5 Seymour-grove, Old Trafford, Manchester.
1888. ‡Etheridge, Mrs. 14 Carlyle-square, S.W.
1901. ‡Ettersbank, John. Care of Messrs. Dalgety & Co., 52 Lombard-street, E.C.
1889. *Evans, A. H., M.A. 9 Harvey-road, Cambridge.
1870. *Evans, Arthur John, M.A., F.R.S., F.S.A. (Pres. H, 1896). Youlbury, Abingdon.
1865. *Evans, Rev. Charles, M.A. Parkstone, Dorset.
1896. ‡Evans, Edward, jun. Spital Old Hall, Bromborough, Cheshire.
1891. ‡Evans, Franklen. Llwynarthen, Castleton, Cardiff.
1889. ‡Evans, Henry Jones. Greenhill, Whitchurch, Cardiff.
1887. *Evans, Mrs. Isabel. Hoghton Hall, Hoghton, near Preston.
1883. *Evans, James C. 38 Crescent-road, Birkdale, Southport.
1883. *Evans, Mrs. James C. 38 Crescent-road, Birkdale, Southport.
1861. *Evans, Sir John, K.C.B., D.C.L., LL.D., D.Sc., F.R.S., F.S.A., F.L.S., F.G.S. (President, 1897; Pres. C, 1878; Pres. H, 1890; Council 1868-74, 1875-82, 1889-96). Nash Mills, Hemel Hempstead.
1897. *Evans, Lady. Nash Mills, Hemel Hempstead.
1898. ‡Evans, Jonathan L. 4 Litfield-place, Clifton, Bristol.
1881. ‡Evans, Lewis. Llanfyrnach, R.S.O., Pembrokeshire.
1885. *Evans, Percy Bagnall. The Spring, Kenilworth.
1865. ‡Evans, Sebastian, M.A., LL.D. Canterbury.
1899. ‡Evans, Mrs. Canterbury.
1865. *Evans, William. The Spring, Kenilworth.
1891. ‡*Evan-Thomas, C., J.P. The Gnoll, Neath, Glamorganshire.*
1903. §Evatt, E. J., M.B. 8 Kyveilog-street, Cardiff.
1871. ‡Eve, H. Weston, M.A. 37 Gordon-square, W.C.
1868. *Everett, J. D., M.A., D.C.L., F.R.S., F.R.S.E. 11 Leopold-road, Ealing, W.
1902. *Everett, Percy W. Oaklands, Elstree, Hertfordshire.
1895. ‡Everett, W. H., B.A. University College, Nottingham.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1886. ‡Everitt, William E. Finstall Park, Bromsgrove.
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡Ewart, J. Cossar, M.D., F.R.S. (Pres. D, 1901), Professor of Natural History in the University of Edinburgh.
1874. ‡Ewart, Sir W. Quartus, Bart. (Local Sec. 1874). Glenmachan, Belfast.
1876. *Ewing, James Alfred, M.A., B.Sc., F.R.S., F.R.S.E., M.Inst. C.E. Royal Naval College, Greenwich, S.E.
1883. ‡Ewing, James L. 52 North Bridge, Edinburgh.
1903. §Ewing, Peter, F.L.S. The Frond, Uddingston, Glasgow.
1884. *Eyerman, John, F.Z.S. Oakhurst, Easton, Pennsylvania, U.S.A.
1882. ‡Eyre, G. E. Briscoe. Warrens, near Lyndhurst, Hants.
Eyton, Charles. Hendred House, Abingdon.

1890. ‡Faber, Edmund Beckett. Straylea, Harrogate.
1896. ‡Fairbrother, Thomas. 46 Lethbridge-road, Southport.
1901. §Fairgrieve, M. McCallum. 115 Dalkeith-road, Edinburgh.
1865. *Fairley, Thomas, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1896. §Falk, Herman John, M.A. Thorshill, West Kirby, Cheshire.
1902. §Fallaize, E. N., M.A. 25 Alexandra-mansions, Middle-lane, Hornsey, N.
1898. §Faraday, Miss Ethel R., M.A. Ramsay Lodge, Levenshulme, near Manchester.

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Year of Election.

1877. §FARADAY, F. J., F.L.S., F.S.S. (Local Sec. 1887). College-chambers, 17 Brazennose-street, Manchester.
1902. §Faren, William. 11 Mount Charles, Belfast.
1892. *FARMER, J. BRETLAND, M.A., F.R.S., F.L.S., Professor of Botany, Royal College of Science, Exhibition-road, S.W.
1886. ‡Farncombe, Joseph, J.P. Saltwood, Spencer-road, Eastbourne.
1897. *Farnworth, Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1897. *Farnworth, Mrs. Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1883. ‡Farnworth, William. 86 Preston New-road, Blackburn.
1885. ‡Farquhar, Admiral. Carlogie, Aberdeen.
1886. ‡FARQUHARSON, Colonel Sir J., K.C.B., R.E. Corrachee, Tarland, Aberdeen.
1859. ‡Farquharson, Robert F. O. Tillydrine, Kincardine O'Neil, N.B.
1885. *Farquharson, Mrs. R. F. O. Tillydrine, Kincardine O'Neil, N.B.
1883. ‡Farrell, John Arthur. Moynalty, Kells, North Ireland.
1897. ‡Farthing, Rev. J. C., M.A. The Rectory, Woodstock, Ontario, Canada.
1869. *Faulding, Joseph. Boxley House, Tenterden, Kent.
1883. ‡Faulding, Mrs. Boxley House, Tenterden, Kent.
1887. §Faulkner, John. 13 Great Ducie-street, Strangeways, Manchester.
1890. *Fawcett, F. B. University College, Bristol.
1900. ‡FAWCETT, J. E., J.P. (Local Sec. 1900). Low Royd, Apperley Bridge, Bradford.
1902. *Fawsitt, C. E., Ph.D. 9 Foremount-terrace, Dowanhill, Glasgow.
1901. *Fearnsides, W. G., B.A., F.G.S. Sidney Sussex College, Cambridge.
1886. ‡Felkin, Robert W., M.D., F.R.G.S. 48 Westbourne-gardens, Bayswater, W.
1900. *Fennell, W. John. Deramore Drive, Belfast.
1883. ‡Fenwick, E. H. 29 Harley-street, W.
1890. ‡Fenwick, T. Chapel Allerton, Leeds.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1883. ‡Ferguson, Mrs. A. A. 11 Grosvenor-terrace, Glasgow.
1902. ‡FERGUSON, GODFREY W. (Local Sec. 1902). Cluan, Donegal Park, Belfast.
1871. *FERGUSON, JOHN, M.A., LL.D., F.R.S.E., F.S.A., F.C.S., Professor of Chemistry in the University of Glasgow.
1896. *Ferguson, John. Colombo, Ceylon.
1867. ‡Ferguson, Robert M., LL.D., Ph.D., F.R.S.E. 5 Learmonth-terrace, Edinburgh.
1901. §Ferguson, R. W. The Intermediate School, Newport, Monmouthshire.
1883. ‡Fernald, H. P. Clarence House, Promenade, Cheltenham.
1883. *Fernie, John. Box No. 2, Hutchinson, Kansas, U.S.A.
1873. ‡FERRIER, DAVID, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College, London. 34 Cavendish-square, W.
1892. ‡Ferrier, Robert M., B.Sc., Professor of Engineering, University College, Bristol.
1897. ‡Ferrier, W. F. Geological Survey, Ottawa, Canada.
1897. ‡Fessenden, Reginald A., Professor of Electrical Engineering, University, Alleghany, Pennsylvania, U.S.A.
1882. §Fewings, James, B.A., B.Sc. King Edward VI. Grammar School Southampton.
1887. ‡Fiddes, Thomas, M.D. Penwood, Urmston, near Manchester.
1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.
1868. ‡Field, Edward. Norwich.
1897. ‡Field, George Wilton, Ph.D. Experimental Station, Kingston, Rhode Island, U.S.A.

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Year of Election.

1886. ‡*Field, H. C.* 4 *Carpenter-road, Edgbaston, Birmingham.*
1882. ‡Filliter, Freeland. St. Martin's House, Wareham, Dorset.
1883. *Finch, Gerard B., M.A. 1 St. Peter's-terrace, Cambridge.
1878. *Findlater, Sir William. 22 Fitzwilliam-square, Dublin.
1884. ‡Finlay, Samuel. Montreal, Canada.
1902. §Finnegan, J., B.A., B.Sc. Kelvin House, Botanic-avenue, Belfast.
1887. ‡Finnemore, Rev. J., M.A., Ph.D., F.G.S. 88 Upper Hanover-street, Sheffield.
1881. ‡Firth, Colonel Sir Charles. Heckmondwike.
1895. §Fish, Frederick J. Spursholt, Park-road, Ipswich.
1891. ‡Fisher, Major H. O. The Highlands, Llandough, near Cardiff.
1902. ‡Fisher, J. R. Cranfield, Fortwilliam Park, Belfast.
1884. *Fisher, L. C. Galveston, Texas, U.S.A.
1869. ‡Fisher, Rev. Osmond, M.A., F.G.S. Harlton Rectory, near Cambridge.
1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1887. *Fison, Alfred H., D.Sc. 25 Blenheim-gardens, Willesden Green, N.W.
1885. ‡Fison, E. Herbert. Stoke House, Ipswich.
1871. *Fison, Frederick W., M.A., M.P., F.C.S. 64 Pont-street, S.W.
1883. ‡Fitch, Rev. J. J. 5 Chambres-road, Southport.
1878. ‡Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.
1885. *FitzGerald, Professor Maurice, B.A. (Local Sec. 1902). 32 Eglantine-avenue. Belfast.
1804. ‡Fitzmaurice, M., C.M.G., M.Inst.C.E. London County Council, Spring-gardens, S.W.
1888. *Fitzpatrick, Rev. Thomas C. Christ's College, Cambridge.
1897. ‡Flavelle, J. W. 565 Jarvis-street, Toronto, Canada.
1881. ‡Fleming, Rev. Canon J., B.D. St. Michael's Vicarage, Ebury-square, S.W.
1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, Glasgow.
1876. ‡Fleming, Sir Sandford, K.C.M.G., F.G.S. Ottawa, Canada.
1867. ‡Fletcher, Alfred E., F.C.S. Delmore, Caterham, Surrey.
1870. ‡Fletcher, B. Edgington. Marlingford Hall, Norwich.
1890. ‡Fletcher, B. Morley. 7 Victoria-street, S.W.
1892. ‡Fletcher, George, F.G.S. Dawson Court, Blackrock, co. Dublin.
1888. *Fletcher, Lazarus, M.A., F.R.S., F.G.S., F.C.S. (Pres. C, 1894), Keeper of Minerals, British Museum (Natural History), Cromwell-road, S.W. 35 Woodville-gardens, Ealing, W.
1901. ‡Flett, J. S., M.A., D.Sc., F.R.S.E. 28 Jermyn-street, S.W.
1889. ‡Flower, Lady. 26 Stanhope-gardens, S.W.
1877. *Floyer, Ernest A. Camberley, Surrey.
1890. *Flux, A. W., M.A., Professor of Political Economy in the University, Montreal, Canada.
1877. ‡Foale, William. The Croft, Madeira Park, Tunbridge Wells.
1891. ‡Foldvary, William. Museum Ring, 10, Buda Pesth.
1903. §Foord-Kelcey, W., Professor of Mathematics in the Royal Military Academy, Woolwich. The Shrubbery, Shooter's Hill, S.E.
1880. ‡Foote, R. Bruce, F.G.S. Care of Messrs. H. S. King & Co., 65 Cornhill, E.C.
1873. *Forbes, George, M.A., F.R.S., F.R.S.E., M.Inst.C.E. 34 Great George-street, S.W.
1883. ‡Forbes, Henry O., LL.D., F.Z.S., Director of Museums for the Corporation of Liverpool. The Museum, Liverpool.
1897. ‡Forbes, J., K.C. Hazeldean, Putney-hill, S.W.
1885. ‡Forbes, The Right Hon. Lord. Castle Forbes, Aberdeenshire.
1890. ‡Ford, J. Rawlinson (Local Sec. 1890). Quarry Dene, Weetwood-lane, Leeds.

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Year of Election.

1875. *Fordham, H. George. Odsey, Ashwell, Baldock, Herts.
1894. ‡*Forrest, Frederick. Beechwood, Castle Hill, Hastings.*
1887. ‡Forrest, The Right Hon. Sir John, G.C.M.G., F.R.G.S., F.G.S. Perth, Western Australia.
1902. §Forster, M. O., Ph.D. Royal College of Science, S.W.
1883. ‡Forsyth, A. R., M.A., D.Sc., F.R.S. (Pres. A, 1897), Sadlerian Professor of Pure Mathematics in the University of Cambridge. Trinity College, Cambridge.
1900. ‡Forsyth, D. Central Higher Grade School, Leeds.
1884. ‡Fort, George H. Lakefield, Ontario, Canada.
1877. ‡Fortescue, The Right Hon. the Earl. Castle Hill, North Devon.
1896. ‡Forwood, Sir William B., J.P. Ramleh, Blundellsands, Liverpool.
1875. ‡Foster, A. Le Neve. 51 Cadogan-square, S.W.
1865. ‡Foster, Sir B. Walter, M.D., M.P. 16 Temple-row, Birmingham.
1865. *Foster, Sir Clement Le Neve, B.A., D.Sc., F.R.S., F.G.S., Professor of Mining in the Royal College of Science, London, S.W.
1883. ‡Foster, Lady.
1857. *Foster, George Carey, B.A., LL.D., D.Sc., F.R.S. (General Treasurer, 1898– ; Pres. A, 1877; Council 1871-76, 1877-82). Ladywalk, Rickmansworth.
1896. ‡Foster, Miss Harriet. Cambridge Training College, Wollaston-road, Cambridge.
1859. *Foster, Sir Michael, K.C.B., M.P., M.A., M.D., LL.D., D.C.L., F.R.S., F.L.S. (President, 1899; Gen. Sec. 1872–76; Pres. I, 1897; Council, 1871–72). Great Shelford, Cambridge.
1901. §Foster, T. Gregory, Ph.D. University College, W.C.; and Chester-road, Northwood, Middlesex.
1903. §Fourcade, H. G. Cape Town.
1896. ‡Fowkes, F. Hawkshead, Ambleside.
1866. ‡Fowler, George, M.Inst.C.E., F.G.S. Basford Hall, near Nottingham.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1892. ‡Fowler, Miss Jessie A. 4 & 5 Imperial-buildings, Ludgate-circus, E.C.
1901. ‡Fowlis, William. 45 John-street, Glasgow.
1883. *Fox, Charles. The Pynes, Warlingham-on-the-Hill, Surrey.
1883. §Fox, Sir Charles Douglas, M.Inst.C.E. (Pres. G, 1896). 28 Victoria-street, Westminster, S.W.
1896. ‡Fox, Henry J. Bank's Dale, Bromborough, near Liverpool.
1883. ‡Fox, Howard, F.G.S. Rosehill, Falmouth.
1847. *Fox, Joseph Hoyland. The Clive, Wellington, Somerset.
1900. *Fox, Thomas. Pyles Thorne House, Wellington, Somerset.
1881. *Foxwell, Herbert S., M.A., F.S.S. (Council 1894–97), Professor of Political Economy in University College, London. St. John's College, Cambridge.
1889. ‡Frain, Joseph, M.D. Grosvenor-place, Jesmond, Newcastle-upon-Tyne.
Francis, William, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, E.C.; and Manor House, Richmond, Surrey.
1887. *Frankland, Percy F., Ph.D., B.Sc., F.R.S. (Pres. B, 1901), Professor of Chemistry in the University of Birmingham.
1894. ‡Franklin, Mrs. E. L. 50 Porchester-terrace, W.
1895. §Fraser, Alexander. 63 Church-street, Inverness.
1882. *Fraser, Alexander, M.B., Professor of Anatomy in the Royal College of Surgeons, Dublin.
1885. ‡Fraser, Angus, M.A., M.D., F.C.S. (Local Sec. 1885). 232 Union-street, Aberdeen.
1865. *Fraser, John, M.A., M.D., F.G.S. Chapel Ash, Wolverhampton.

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Year of Election.

1871. ‡FRASER, Sir THOMAS R., M.D., F.R.S., F.R.S.E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1884. *Frazer, Persifor, M.A., D.Sc. (Univ. de France). Room 1042, Drexel Building, Philadelphia, U.S.A.
1884. *FREAM, W., LL.D., B.Sc., F.L.S., F.G.S., F.S.S. The Vinery, Downton, Salisbury.
1877. §Freeman, Francis Ford. Abbotsfield, Tavistock, South Devon.
1884. *FREMANTLE, The Hon. Sir C. W., K.C.B. (Pres. F, 1892; Council 1897–1903). 4 Lower Sloane-street, S.W.
1886. ‡FRESHFIELD, DOUGLAS W., F.R.G.S. 1 Airlie-gardens, Campden Hill, W.
1901. §Frew, William, Ph.D. King James-place, Perth.
1887. ‡Fries, Harold H, Ph.D. 92 Reade-street, New York, U.S.A.
1892. *Frost, Edmund, M.B. Chesterfield-road, Eastbourne.
1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.
1887. *Frost, Robert, B.Sc. 53 Victoria-road, W.
1899. ‡Fry, Edward W. Cannon-street, Dover.
1898. ‡FRY, The Right Hon. Sir EDWARD, D.C.L., LL.D., F.R.S., F.S.A. Failand House, Failand, near Bristol.
1898. ‡*Fry, Francis J. Leigh Woods, Clifton, Bristol.*
1875. *Fry, Joseph Storrs. 17 Upper Belgrave-road, Clifton, Bristol.
1898. ‡Fryer, Alfred C., Ph.D. 13 Eaton-crescent, Clifton, Bristol.
1884. ‡Fryer, Joseph, J.P. Smelt House, Howden-le-Wear, Co. Durham.
1895. ‡FULLARTON, Dr. J. H. Fishery Board for Scotland, George-street, Edinburgh.
1872. *Fuller, Rev. A. 7 Sydenham-hill, Sydenham, S.E.
1859. ‡FULLER, FREDERICK, M.A. (Local Sec. 1859). 9 Palace-road, Surbiton.
1869. ‡FULLER, G., M.Inst.C.E. (Local Sec. 1874). 71 Lexham-gardens, Kensington, W.
1884. ‡Fuller, William, M.B. Oswestry.
1891. ‡*Fulton, Andrew.* 23 *Park-place, Cardiff.*

1887. ‡Gaddum, G. H. Adria House, Toy-lane, Withington, Manchester.
1863. *Gainsford, W. D. Skendleby Hall, Spilsby.
1896. ‡Gair, H. W. 21 Water-street, Liverpool.
1850. ‡GAIRDNER, Sir W. T., K.C.B., M.D., LL.D., F.R.S. 32 George-square, Edinburgh.
1876. ‡Gale, James M. 23 Miller-street, Glasgow.
1885 *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1889. ‡Galloway, Walter. Eighton Banks, Gateshead.
1875. ‡GALLOWAY, W. Cardiff.
1887. *Galloway, W. J., M.P. The Cottage, Seymour-grove, Old Trafford, Manchester.
1899. §Galton, Lady Douglas. Himbleton Manor, Droitwich.
1860. *GALTON, FRANCIS, M.A., D.C.L., D.Sc., F.R.S., F.R.G.S. (GEN. SEC. 1863–68; Pres. E, 1862, 1872; Pres. H, 1885; Council 1860–63). 42 Rutland-gate, Knightsbridge, S.W.
1869. ‡GALTON, JOHN C., M.A., F.L.S. New University Club, St. James's-street, S.W.
1870. §Gamble, Lieut.-Colonel Sir D., Bart., C.B. St. Helens, Lancashire.
1889. ‡Gamble, David. Ratonagh, Colwyn Bay.
1870. ‡Gamble J. C. St. Helens, Lancashire.

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Year of Election.

1888. *Gamble, J. Sykes, C.I.E., M.A., F.R.S., F.L.S. Highfield, East Liss, Hants.
1877. ‡Gamble, William. St. Helens, Lancashire.
1868. ‡Gamgee, Arthur, M.D., F.R.S. (Pres. D, 1882; Council 1888–90). 5 Avenue du Kursaal, Montreux, Switzerland.
1899. *Garcke, E. Ditton House, near Maidenhead.
1898. §Garde, Rev. C. L. Skenfrith Vicarage, near Monmouth.
1900. §Gardiner, J. Stanley, M.A. Dunstall, Newton-road, Cambridge.
1887. ‡Gardiner, Walter, M.A., F.R.S. 45 Hills-road, Cambridge.
1882. *Gardner, H. Dent, F.R.G.S. Fairmead, 46 The Goffs, Eastbourne.
1896. ‡Gardner, James. The Groves, Grassendale, Liverpool.
1894. ‡*Gardner, J. Addyman. 5 Bath-place, Oxford.*
1882. ‡Gardner, John Starkie. 29 Albert Embankment, S.E.
1884. ‡Garman, Samuel. Cambridge, Massachusetts, U.S.A.
1887. *Garnett, Jeremiah. The Grange, Bromley Cross, near Bolton, Lancashire.
1882. ‡Garnett, William, D.C.L. London County Council, Spring-gardens, S.W.
1873. ‡Garnham, John. Hazelwood, Crescent-road, St. John's, Brockley, Kent, S.E.
1883. ‡Garson, J. G., M.D. (Assistant General Secretary.) 14 Stratford-place, W.
1903. §Garstang, A. H. 20 Roe-lane, Southport.
1903. *Garstang, T. James, M.A. Bedale's School, Petersfield, Hampshire.
1894. *Garstang, Walter, M.A., F.Z.S. Marine Biological Laboratory, Plymouth.
1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragansstown, Castlebellingham, Ireland.
1882. ‡Garton, William. Woolston, Southampton.
1892. ‡*Garvie, James. Bolton's Park, Potter's Bar.*
1889. ‡Garwood, Professor E. J., M.A., F.G.S. University College, Gower-street, W.C.
1870. *Gaskell, Holbrook. Bridge House, Sefton Park, Liverpool.
1896. *Gaskell, Walter Holbrook, M.A., M.D., LL.D., F.R.S. (Pres. I, 1896; Council 1898–1901). The Uplands, Great Shelford, near Cambridge.
1896. ‡Gatehouse, Charles. Westwood, Noctorum, Birkenhead.
1862. *Gatty, Charles Henry, M.A., LL.D., F.R.S.E., F.L.S., F.G.S. Felbridge Place, East Grinstead, Sussex.
1875. ‡Gavey, J. Hollydale, Hampton Wick, Middlesex.
1892. ‡Geddes, George H. 8 Douglas-crescent, Edinburgh.
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1885. ‡Geddes, Professor Patrick. Ramsay-garden, Edinburgh.
1887. ‡*Gee, W. W. Haldane. Owens College, Manchester.*
1867. ‡Geikie, Sir Archibald, LL.D., D.Sc., Sec.R.S., F.R.S.E., F.G.S. (President, 1892; Pres. C, 1867, 1871, 1899; Council 1888–91). 10 Chester-terrace, Regent's-park, N.W.
1871. ‡Geikie, James, LL.D., D.C.L., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1889; Pres. E, 1892), Murchison Professor of Geology and Mineralogy in the University of Edinburgh. Kilmorie, Colinton-road, Edinburgh.
1898. §Gemmill, James F., M.A., M.B. 21 Endsleigh-gardens, Partickhill, Glasgow.
1882. *Genese, R. W., M.A., Professor of Mathematics in University College, Aberystwyth.
1875. *George, Rev. Hereford Brooke, M.A., F.R.G.S. Holywell Lodge, Oxford.

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Year of Election.

1902. *Gepp, Antony, M.A., F.L.S. British Museum (Natural History), Cromwell-road, S.W.
1899. *Gepp, Mrs. A. 26 West Park-gardens, Kew.
1885. ‡Gerard, Robert. Blair-Devenick, Cults, Aberdeen.
1884. *Gerrans, Henry T., M.A. 20 St. John-street, Oxford.
1884. ‡Gibb, Charles. Abbotsford, Quebec, Canada.
1865. ‡*Gibbins, William. Battery Works, Digbeth, Birmingham.*
1902. ‡Gibson, Andrew. 14 Cliftonville-avenue, Belfast.
1874. ‡Gibson, The Right Hon. Edward, K.C. 23 Fitzwilliam-square, Dublin.
1892. ‡Gibson, Francis Maitland. Care of Professor Gibson, 20 George-square, Edinburgh.
1901. §Gibson, Professor George A., M.A. 183 Renfrew-street, Glasgow.
1876. *Gibson, George Alexander, M.D., D.Sc., F.R.S.E. 3 Drumsheugh-gardens, Edinburgh.
1892. ‡Gibson, James. 20 George-square, Edinburgh.
1884. ‡Gibson, Rev. James J. 183 Spadina-avenue, Toronto, Canada.
1898. ‡Gibson, R. J. Harvey, M.A., F.R.S.E., Professor of Botany in the University of Liverpool.
1889. *Gibson, T. G. Lesbury House, Lesbury, R.S.O., Northumberland.
1893. ‡Gibson, Walcot, F.G.S. 28 Jermyn-street, S.W.
1887. *Giffen, Sir Robert, K.C.B., LL.D., F.R.S., V.P.S.S. (Pres. F, 1887, 1901). Chanctonbury, Hayward's Heath.
1898. *Gifford, J. William. Oaklands, Chard.
1884. ‡Gilbert E. E. 245 St. Antoine-street, Montreal, Canada.
1883. §Gilbert, Lady. Harpenden, near St. Albans.
1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.
1884. *Gilbert, Philip H. 63 Tupper-street, Montreal, Canada.
1895. ‡Gilchrist, J. D. F. Carvenon, Anstruther, Scotland.
1896. *Gilchrist, Percy C., F.R.S., M.Inst.C.E. Frognal Bank, Finchley-road, Hampstead, N.W.
1878. ‡Giles, Oliver. Brynteg, The Crescent, Bromsgrove.
1871. *Gill, Sir David, K.C.B., LL.D., F.R.S., F.R.A.S. Royal Observatory, Cape Town.
1902. §Gill, James F. 72 Strand-road, Bootle, Liverpool.
1884. ‡Gillman, Henry. 130 Lafayette-avenue, Detroit, Michigan, U.S.A.
1892. *Gilmour, Matthew A. B., F.Z.S. Saffronhall House, Windmill-road, Hamilton, N.B.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1893. *Gimingham, Edward. 1 Cranbourn-mansions, Cranbourn-street, W.C.
1904. §Ginn, S. R. (Local Sec. 1904). Brookfield, Trumpington-road, Cambridge.
1900. §Ginsburg, Benedict W., M.A., LL.D. 23 Ladbroke-square, W.
1867. ‡Ginsburg, Rev. C. D., D.C.L., LL.D. Holmlea, Virginia Water Station, Chertsey.
1884. ‡Girdwood, Dr. G. P. 28 Beaver Hall-terrace, Montreal, Canada.
1886. *Gisborne, Hartley, M.Can.S.C.E. Caragana Lodge, Ladysmith, Vancouver Island, Canada.
1850. *Gladstone, George, F.R.G.S. 34 Denmark-villas, Hove, Brighton.
1883. *Gladstone, Miss. 19 Chepstow-villas, Bayswater, W.
1871. *Glaisher, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. (Pres. A, 1890; Council 1878–86). Trinity College, Cambridge.
1901. ‡Glaister, Professor John, M.D., F.R.S.E. 18 Woodside-place, Glasgow.
1897. ‡Glashan, J. C., LL.D. Ottawa, Canada.

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Year of Election.

1883. †Glasson, L. T. 2 Roper-street, Penrith.
1881. *Glazebrook, R. T., M.A., D.Sc., F.R.S., Director of the National Physical Laboratory (Pres. A, 1893; Council 1890–94). Bushy House, Teddington, Middlesex.
1881. *Gleadow, Frederic. 38 Ladbroke-grove, W.
1859. †Glennie, J. S. Stuart, M.A. Sandycroft, Haslemere, Surrey.
1874. †*Glover, George T. Corby, Hoylake.*
Glover, Thomas. 124 Manchester-road, Southport.
1870. †Glynn, Thomas R., M.D. 62 Rodney-street, Liverpool.
1872. †Goddard, Richard (Local Sec. 1873). 16 Booth-street, Bradford, Yorkshire.
1899. §Godfrey, Ingram F. Brooke House, Ash, Dover.
1886. †Godlee, Arthur. The Lea, Harborne, Birmingham.
1887. †Godlee, Francis. 8 Minshall-street, Manchester.
1878. *Godlee, J. Lister. Wakes Colne Place, Essex.
1880. †Godman, F. Du Cane, D.C.L., F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, W.
1883. †Godson, Dr. Alfred. Cheadle, Cheshire.
1852. †Godwin, John. Wood House, Rostrevor, Belfast.
1879. †Godwin-Austen, Lieut.-Colonel H. H., F.R.S., F.R.G.S., F.Z.S. (Pres. E, 1883). Nore, Godalming.
1876. †Goff, Bruce, M.D. Bothwell, Lanarkshire.
1898. †Goldney, F. B. Goodnestone Park, Dover.
1881. †Goldschmidt, Edward, J.P. Nottingham.
1886. †Goldsmid, Major-General Sir F. J., K.C.S.I., C.B., F.R.G.S. (Pres. E, 1886). Godfrey House, Hollingbourne.
1899. †Gomme, G. L., F.S.A. 24 Dorset-square, N.W.
1890. *Gonner, E. C. K., M.A. (Pres. F, 1897), Professor of Political Economy in the University of Liverpool.
1884. †Good, Charles E. 102 St. François Xavier-street, Montreal, Canada.
1852. †Goodbody, Jonathan. Clare, King's County, Ireland.
1878. †Goodbody, Jonathan, jun. 50 Dame-street, Dublin.
1884. †Goodbody, Robert. Fairy Hill, Blackrock, Co. Dublin.
1884. *Goodridge, Richard E. W. Lupton, Michigan, U.S.A.
1884. †Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1885. †Gordon, Rev. Cosmo, D.D., F.R.A.S. Chetwynd Rectory, Newport, Salop.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's-mansions, Westminster, S.W.
1893. †Gordon, Mrs. M. M., D.Sc. 1 Rubislaw-terrace, Aberdeen.
1884. *Gordon, Robert, M.Inst.C.E., F.R.G.S. Fairview, Dartmouth, Devon.
1885. †Gordon, Rev. William. Braemar, N.B.
1865. †Gore, George, LL.D., F.R.S. 20 Easy-row, Birmingham.
1901. §Gorst, Right Hon. Sir John E., M.A., K.C., M.P., F.R.S. (Pres. L, 1901). Queen Anne's-mansions, S.W.
1875. *Gotch, Francis, M.A., B.Sc., F.R.S. (Council, 1901–), Professor of Physiology in the University of Oxford. The Lawn, Banbury-road, Oxford.
1873. †Gott, Charles, M.Inst.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.
1849. †Gough, The Hon. Frederick. Perry Hall, Birmingham.
1881. †Gough, Rev. Thomas, B.Sc. King Edward's School, Retford.
1894. †Gould, G. M., M.D. 119 South 17th-street, Philadelphia, U.S.A.
1888. †Gouraud, Colonel. Gwydyr-mansions, Hove, Sussex.

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Year of Election.

1901. †Gourlay, Robert. Glasgow.
1901. §Gow, Leonard. Hayston, Kelvinside, Glasgow.
1876. †Gow, Robert. Cairndowan, Dowanhill-gardens, Glasgow.
1883. §Gow, Mrs. Cairndowan, Dowanhill-gardens, Glasgow.
1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1886. †Grabham, Michael C., M.D. Madeira.
1901. †Graham, Robert. 165 Nithsdale-road, Pollokshields, Glasgow.
1902. *Graham, William, M.D. District Lunatic Asylum, Belfast.
1875. †Grahame, James (Local Sec. 1876). Reform Club, Pall Mall, S.W.
1892. †Grange, C. Ernest. 57 Berners-street, Ipswich.
1893. †Granger, Professor F. S., M.A., D.Litt. 2 Cranmer-street, Nottingham.
1896. †Grant, Sir James, K.C.M.G. Ottawa, Canada.
1892. †Grant, W. B. 10 Ann-street, Edinburgh.
1864. †Grantham, Richard F., M.Inst.C.E., F.G.S. Northumberland-chambers, Northumberland-avenue, W.C.
1881. †Gray, Alan, LL.B. Minster-yard, York.
1899. †Gray, Albert Alexander. 16 Berkeley-terrace, Glasgow.
1890. †Gray, Andrew, M.A., LL.D., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Glasgow.
1899. †Gray, Charles. 11 Portland-place, W.
1902. †Gray, G., M.D. Newcastle, Co. Down.
1864. *Gray, Rev. Canon Charles. West Retford Rectory, Retford.
1876. †Gray, Dr. Newton-terrace, Glasgow.
1881. †Gray, Edwin, LL.B. Minster-yard, York.
1903. §Gray, Ernest, M.A., M.P. 99 Grosvenor-road, S.W.
1893. †Gray, J. C., General Secretary of the Co-operative Union, Limited, Long Millgate, Manchester.
1892. *Gray, James Hunter, M.A., B.Sc. 141 Hopton-road, Streatham, S.W.
1870. †Gray, J. Macfarlane. 4 Ladbroke-crescent, W.
1892. §Gray, John, B.Sc. 9 Park-hill, Clapham Park, S.W.
1887. †Gray, Joseph W., F.G.S. St. Elmo, Leckhampton-road, Cheltenham.
1887. †Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.
1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.
1901. †Gray, R. W. 7 Orme-court, Bayswater, W.
1881. †Gray, Thomas, Professor of Engineering in the Rane Technical Institute, Terre Haute, Indiana, U.S.A.
1873. †Gray, William, M.R.I.A. Glenburn Park, Belfast.
*Gray, Colonel William. Farley Hall, near Reading.
1883. †Gray, William Lewis. Westmoor Hall, Brimsdown, Middlesex.
1883. †Gray, Mrs. W. L. Westmoor Hall, Brimsdown, Middlesex.
1886. †Greaney, Rev. William. Bishop's House, Bath-street, Birmingham.
1866. §Greaves, Charles Augustus, M.B., LL.B. 84 Friar-gate, Derby.
1893. *Greaves, Mrs. Elizabeth. Station-street, Nottingham.
1869. †Greaves, William. Station-street, Nottingham.
1872. †Greaves, William. 33 Marlborough-place, N.W.
1872. *Grece, Clair J., LL.D. 146 Station-road, Redhill, Surrey.
1888. §Green, J. Reynolds, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1902), Professor of Botany to the Pharmaceutical Society of Great Britain. 61A St. Andrew's-street, Cambridge.
1903. §Green, W. J. 22 Sheepcote-road, Harrow.
1882. †Greenhill, A. G., M.A., F.R.S., Professor of Mathematics in the Royal Artillery College, Woolwich. 1 Staple Inn, W.C.

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Year of Election.

1881. ‡Greenhough, Edward. Matlock Bath, Derbyshire.
1884. ‡Greenish, Thomas, F.C.S. 20 New-street, Dorset-square, N.W.
1898. *Greenly, Edward. Achnashean, near Bangor, North Wales.
1884. ‡Greenshields, E. B. Montreal, Canada.
1884. ‡Greenshields, Samuel. Montreal, Canada.
1887. ‡Greenwell, G. C. Beechfield, Poynton, Cheshire.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1890. ‡Greenwood, Arthur. Cavendish-road, Leeds.
1875. ‡Greenwood, F., M.B. Brampton, Chesterfield.
1887. ‡Greenwood, W. H., M.Inst.C.E. Adderley Park Rolling Mills, Birmingham.
1887. *Greg, Arthur. Eagley, near Bolton, Lancashire.
1861. *Greg, Robert Philips, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1894. *Gregory, Professor J. Walter, D.Sc., F.R.S., F.G.S. The University, Melbourne, Australia.
1896. *Gregory, Professor R. A., F.R.A.S. Dell Quay House, near Chichester.
1883. ‡Gregson, G. E. Ribble View, Preston.
1881. ‡Gregson, William, F.G.S. Baldersby, S.O., Yorkshire.
1859. ‡Grierson, Thomas Boyle, M.D. Thornhill, Dumfriesshire.
1878. ‡Griffin, Robert, M.A., LL.D. Trinity College, Dublin.
1836. Griffin, S. F. Albion Tin Works, York-road, N.
1894. *Griffith, C. L. T., Assoc.M.Inst.C.E. Selworthy, College-road, Harrow.
1884. ‡Griffiths, E. H., M.A., D.Sc., F.R.S. University College, Cardiff.
1884. ‡Griffiths, Mrs. University College, Cardiff.
1891. ‡Griffiths, P. Rhys, B.Sc., M.B. 71 Newport-road, Cardiff.
1903. §Griffiths, Thomas, J.P. 101 Manchester-road, Southport.
1847. ‡Griffiths, Thomas. The Elms, Harborne-road, Edgbaston, Birmingham.
1870. ‡Grimsdale, T. F., M.D. Hoylake, Liverpool.
1888. *Grimshaw, James Walter, M.Inst C.E. Australian Club, Sydney, New South Wales.
1884. ‡Grinnell, Frederick. Providence, Rhode Island, U.S.A.
1894. ‡Groom, Professor P., M.A., F.L.S. Hollywood, Egham, Surrey.
1894. §Groom, T. T., D.Sc. University College, Reading.
1896. ‡Grossmann, Dr. Karl. 70 Rodney-street, Liverpool.
1892. ‡Grove, Mrs. Lilly, F.R.G.S. The University, Birmingham.
1891. ‡Grover, Henry Llewellin. Clydach Court, Pontypridd.
1869. ‡Grubb, Sir Howard, F.R.S., F.R.A.S. Rockdale, Orwell-road, Rathgar, Dublin.
1897. ‡Grünbaum, A. S., M.A., M.D. 45 Ladbroke-grove, W.
1897. ‡Grünbaum, O. F. F., B.A., D.Sc. 45 Ladbroke-grove, W.
1886. ‡Grundy, John. 17 Private-road, Mapperley, Nottingham.
1891. ‡Grylls, W. London and Provincial Bank, Cardiff.
1887. ‡Guillemard, F. H. H. Eltham, Kent.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1891. ‡Gunn, Sir John. Llandaff House, Llandaff.
1866. ‡Günther, Albert C. L. G., M.A., M.D., Ph.D., F.R.S., F.L.S., F.Z.S. (Pres. D, 1880). 22 Lichfield-road, Kew, Surrey.
1894. ‡Günther, R. T. Magdalen College, Oxford.
1880. §Guppy, John J. Ivy-place, High-street, Swansea.
1902. *Gurney, Robert. The Laboratory, Citadel Hill, Plymouth.
1883. ‡Guthrie, Malcolm. Prince's-road, Liverpool.
1896. ‡*Guthrie, Tom, B.Sc. Yorkshire College, Leeds.*

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Year of Election.

1870. ‡GWYTHER, R. F., M.A. Owens College and 33 Heaton-road, Withington, Manchester.

1884. ‡Haanel, E., Ph.D. Cobourg, Ontario, Canada.
1884. ‡Hadden, Captain C. F., R.A. Woolwich.
1881. *HADDON, ALFRED CORT, M.A., D.Sc., F.R.S., F.Z.S. (Pres. H, 1902; Council, 1902-). Inisfail, Hills-road, Cambridge.
1888. *Hadfield, R. A., M.Inst.C.E. The Grove, Endcliffe Vale-road, Sheffield.
1892. ‡*Haigh, E., M.A. Longton, Staffordshire.*
1870. ‡Haigh, George. 27 Highfield South, Rockferry, Cheshire.
1879. ‡*HAKE, H. WILSON, Ph.D., F.C.S. Queenwood College, Hants.*
1899. ‡Hall, A. D., M.A., Director of the Rothamsted Experiment Station.
1903. §HALL, E. MARSHALL, K.C., M.P. 75 Cambridge-terrace, W.
1903. §Hall, Mrs. 75 Cambridge-terrace, W.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1883. *Hall, Miss Emily. 15 Belmont-street, Southport.
1881. ‡Hall, Frederick Thomas, F.R.A.S. 15 Gray's Inn-square, W.C.
1902. §Hall, Henry Sinclair. 9 The Avenue, Clifton, Bristol.
1854. *HALL, HUGH FERGIE, F.G.S. Cissbury Court, West Worthing, Sussex.
1898. §Hall, James P. The 'Tribune,' New York, U.S.A.
1899. ‡Hall, John, M.D. National Bank of Scotland, 37 Nicholas-lane, E.C.
1885. §Hall, Samuel, F.I.C., F.C.S. 19 Aberdeen-park, Highbury, N.
1900. ‡Hall, T. Farmer, F.R.G.S. 39 Gloucester-square, Hyde Park, W.
1896. ‡Hall, Thomas B. Larch Wood, Rockferry, Cheshire.
1884. ‡Hall, Thomas Proctor. School of Practical Science, Toronto, Canada.
1896. ‡Hall-Dare, Mrs. Caroline. 13 Great Cumberland-place, W.
1891. *Hallett, George. Oak Cottage, West Malvern.
1891. ‡Hallett, J. H., M.Inst.C.E. Maindy Lodge, Cardiff.
1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.
1888. §HALLIBURTON, W. D., M.D., F.R.S. (Pres. I, 1902; Council 1897–1903), Professor of Physiology in King's College, London. Church Cottage, 17 Marylebone-road, N.W.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. Fairley, Weston, Bath.
1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.
1885. ‡Hamilton, David James. 41 Queen's-road, Aberdeen.
1902. ‡HAMILTON, Rev. T., D.D. Queen's College, Belfast.
1881. *Hammond, Robert. 64 Victoria-street, Westminster, S.W.
1899. *Hanbury, Daniel. Lenqua da Cà, Alassio, Italy.
1892. ‡Hanbury, Thomas, F.L.S. La Mortola, Ventimiglia, Italy.
1878. ‡Hance, Edward M., LL.B. 17 Percy-street, Liverpool.
1875. ‡Hancock, C. F., M.A. 125 Queen's-gate, S.W.
1897. ‡*HANCOCK, HARRIS. University of Chicago, U.S.A.*
1861. ‡Hancock, Walter. 10 Upper Chadwell-street, Pentonville, E.C.
1890. ‡Hankin, Ernest Hanbury. St. John's College, Cambridge.
1884. ‡Hannaford, E. P., M.Inst.C.E. 2573 St. Catherine-street, Montreal.
1894. §Hannah, Robert, F.G.S. 82 Addison-road, W.
1886. §Hansford, Charles, J.P. Englefield House, Dorchester.
1902. ‡Harbison, Adam, B.A. 5 Ravenhill-terrace, Ravenhill-road, Belfast.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., F.R.S., V.P.C.S. (GEN. SEC. 1883–97; Pres. B, 1875; Council 1881–83). St. Clare, Ryde, Isle of Wight.

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Year of Election.

1890. *HARCOURT, L. F. VERNON, M.A., M.Inst.C.E. (Pres. G, 1895; Council 1895–1901). 6 Queen Anne's-gate, S.W.
1900. §Harcourt, Hon. R., LL.D., K.C., Minister of Education for the Province of Ontario. Toronto, Canada.
1886. *Hardcastle, Colonel Basil W., F.S.S. 12 Gainsborough-gardens, Hampstead, N.W.
1902. *HARDCASTLE, Miss FRANCES. 14 Huntingdon-road, Cambridge.
1903. *Hardcastle, J. Alfred. The Dial House, Crowthorne, Berkshire.
1892. *HARDEN, ARTHUR, Ph.D., M.Sc. Jenner Institute of Preventive Medicine, Chelsea-gardens, Grosvenor-road, S.W.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1894. ‡Hardman, S. C. 120 Lord-street, Southport.
1894. ‡Hare, A. T., M.A. Neston Lodge, East Twickenham, Middlesex.
1894. ‡Hare, Mrs. Neston Lodge, East Twickenham, Middlesex.
1898. ‡Harford, W. H. Oldown House, Almondsbury.
1858. ‡Hargrave, James. Burley, near Leeds.
1883. ‡Hargreaves, Miss H. M. 69 Alexandra-road, Southport.
1883. ‡Hargreaves, Thomas. 69 Alexandra-road, Southport.
1890. ‡Hargrove, Rev. Charles. 10 De Grey-terrace, Leeds.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York.
1890. *HARKER, ALFRED, M.A., F.R.S., F.G.S. St. John's College, Cambridge.
1896. ‡Harker, Dr. John Allen. Springfield House, Stockport.
1887. ‡Harker, T. H. Brook House, Fallowfield, Manchester.
1871. ‡*Harkness, William, F.C.S.* 1 *St. Mary's-road, Canonbury, N.*
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton.
1883. *Harley, Miss Clara. Rosslyn, Westbourne-road, Forest Hill, S.E.
1883. *Harley, Harold. 14 Chapel-street, Bedford-row, W.C.
1862. *HARLEY, Rev. ROBERT, M.A., F.R.S., F.R.A.S. Rosslyn, Westbourne-road, Forest Hill, S.E.
1899. ‡Harman, Dr. N. Bishop. St. John's College, Cambridge.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., D.Sc., F.R.S. King's College, Cambridge.
1872. ‡Harpley, Rev. William, M.A. Clayhanger Rectory, Tiverton.
1884. ‡Harrington, B. J., B.A., Ph.D., F.G.S., Professor of Chemistry and Mineralogy in McGill University, Montreal. University-street, Montreal, Canada.
1888. ‡Harris, C. T. 4 Kilburn Priory, N.W.
1842. *Harris, G. W., M.Inst.C.E. Millicent, South Australia.
1889. §HARRIS, H. GRAHAM, M.Inst.C.E. 5 Great George-street, Westminster, S.W.
1903. §Harris, Robert, M.B. 18 Duke-street, Southport.
1898. ‡Harrison, A. J., M.D. Failand Lodge, Guthrie-road, Clifton, Bristol.
1888. ‡Harrison, Charles. 20 Lennox-gardens, S.W.
1860. ‡Harrison, Rev. Francis, M.A. North Wraxall, Chippenham.
1889. ‡Harrison, J. C. Oxford House, Castle-road, Scarborough.
1858. *HARRISON, J. PARK, M.A. 22 Connaught-street, Hyde Park, W.
1892. ‡HARRISON, JOHN (Local Sec. 1892). Rockville, Napier-road, Edinburgh.
1870. ‡HARRISON, REGINALD, F.R.C.S. (Local Sec. 1870). 6 Lower Berkeley-street, Portman-square, W.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1892. ‡Harrison, Rev. S. N. Ramsey, Isle of Man.

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Year of Election.

1895. ‡Harrison, Thomas. 48 High-street, Ipswich.
1901. *Harrison, W. E. 15 Lansdowne-road, Handsworth, Staffordshire.
1886. ‡Harrison, W. Jerome, F.G.S. Board School, Icknield-street, Birmingham.
1885. ‡Hart, Colonel C. J. (Local Sec. 1886.) Highfield Gate, Edgbaston, Birmingham.
1876. *Hart, Thomas. Brooklands, Blackburn.
1903. *Hart, Thomas Clifford. Brooklands, Blackburn.
1875. ‡Hart, W. E. Kilderry, near Londonderry.
1893. *Hartland, E. Sidney, F.S.A. Highgarth, Gloucester.
1897. ‡Hartley, E. G. S. Wheaton Astley Hall, Stafford.
1871. *Hartley, Walter Noel, D.Sc., F.R.S., F.R.S.E., F.C.S. (Pres. B, 1903), Professor of Chemistry in the Royal College of Science, Dublin. 36 Waterloo-road, Dublin.
1896. ‡Hartley, W. P., J.P. Aintree, Liverpool.
1886. *Hartog, Professor M. M., D.Sc. Queen's College, Cork.
1887. ‡Hartog, P. J., B.Sc. Owens College, Manchester.
1897. ‡Harvey, Arthur. Rosedale, Toronto, Canada.
1898. ‡Harvey, Eddie. 10 The Paragon, Clifton, Bristol.
1885. §Harvie-Brown, J. A. Dunipace, Larbert, N.B.
1862. *Harwood, John. Woodside Mills, Bolton-le-Moors.
1884. ‡Haslam, Rev. George, M.A. Trinity College, Toronto, Canada.
1893. §Haslam, Lewis. 44 Evelyn-gardens, S.W.
1903. *Hastie, Miss J. A. Care of Messrs. Street & Co., 30 Cornhill, E.C.
1903. §Hastie, William. 20 Elswick-row, Newcastle-on-Tyne.
1875. *Hastings, G. W. (Pres. F, 1880.) Chapel House, Chipping Norton.
1903. §Hastings, W. G. W. Chapel House, Chipping Norton.
1889. ‡Hatch, F. H., Ph.D., F.G.S. 28 Jermyn-street, S.W.
1903. §Hathaway, Herbert G. 45 High-street, Bridgnorth, Salop.
1893. ‡Hatton, John L. S. People's Palace, Mile End-road, E.
1887. *Hawkins, William. Earlston House, Broughton Park, Manchester.
1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, S.W.
1864. *Hawkshaw, John Clarke, M.A., M.Inst.C.E., F.G.S. (Council 1881–87). 22 Down-street, W., and 33 Great George-street, S.W.
1897. §Hawksley, Charles, M.Inst.C.E. (Pres. G, 1903; Council, 1902–). 30 Great George-street, S.W.
1889. ‡Haworth, George C. Ordsal, Salford.
1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.
1890. ‡Hawtin, J. N. Sturdie House, Roundhay-road, Leeds.
1861. *Hay, Admiral the Right Hon. Sir John C. D., Bart., G.C.B., D.C.L., F.R.S. 108 St. George's-square, S.W.
1885. *Haycraft, John Berry, M.D., B.Sc., F.R.S.E., Professor of Physiology in University College, Cardiff.
1891. ‡Hayde, Rev. J. St. Peter's, Cardiff.
1900. §Hayden, H. H. Geological Survey, Calcutta, India.
1903. *Haydock, Arthur. 197 Preston New-road, Blackburn.
1894. ‡Hayes, Edward Harold. 5 Rawlinson-road, Oxford.
1896. ‡Hayes, Rev. F. C. The Rectory, Raheny, Dublin.
1896. ‡Hayes, William. Fernyhurst, Rathgar, Dublin.
1873. *Hayes, Rev. William A., M.A. Dromore, Co. Down, Ireland.
1898. ‡Hayman, C. A. Kingston Villa, Richmond Hill, Clifton, Bristol.
1903. §Hayward, Joseph William, M.Sc. 29 Bishop's-mansions, Fulham, S.W.
1896. *Haywood, Lieut.-Colonel A. G. Rearsby, Merrilocks-road, Blundell-sands.
1879. *Hazelhurst, George S. The Grange, Rockferry.

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Year of Election.

1883. ‡Headley, Frederick Halcombe. Manor House, Petersham, S.W.
1883. ‡Headley, Mrs. Marian. Manor House, Petersham, S.W.
1883. ‡Headley, Rev. Tanfield George. Manor House, Petersham, S.W.
1883. ‡Heape, Charles. Tovrak, Oxton, Cheshire.
1883. ‡Heape, Joseph R. Glebe House, Rochdale.
1882. *Heape, Walter, M.A. Heyroun, Chaucer-road, Cambridge.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1877. ‡Hearder, William Keep. 195 Union-street, Plymouth.
1898. *Heath, Rev. Arthur J., B.A., F.G.S. 71 St. Michael's-hill, Redland, Bristol.
1902. ‡Heath, J W. 33 Upper Gloucester-place, Dorset-square, N.W.
1898. ‡Heath, R. S., M.A., D.Sc. The University, Birmingham.
1884. ‡Heath, Thomas, B.A. Royal Observatory, Edinburgh.
1902. §Heathorn, Captain T. B., R.A. 10 Wilton-place, Knightsbridge, S.W.
1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.
1892. *Heaton, William H., M.A. (Local Sec. 1893), Professor of Physics in University College, Nottingham.
1889. *Heaviside, Arthur West. 7 Grafton-road, Whitley, Newcastle-upon-Tyne.
1884. §Heaviside, Rev. George, B.A., F.R.G.S., F.R.Hist.S. 7 Grosvenor-street, Coventry.
1888. *Heawood, Edward, M.A. 3 Underhill-road, Lordship-lane, S.E.
1888. *Heawood, Percy J., Lecturer in Mathematics at Durham University. 41 Old Elvet, Durham.
1855. ‡Hector, Sir James, K.C.M.G., M.D., F.R.S., F.G.S., Director of the Geological Survey of New Zealand. Wellington, New Zealand.
1887. *Hedges, Killingworth, M.Inst.C.E. 10 Cranley-place, South Kensington, S.W.
1881. *Hele-Shaw, H. S., LL.D., F.R.S., M.Inst.C.E., Professor of Engineering in the University of Liverpool. 27 Ullet-road, Liverpool.
1901. §Heller, W. M., B.Sc. 18 Belgrave-square, Monkstown, Co. Dublin.
1887. §Hembry, Frederick William, F.R.M.S. Langford, Sidcup, Kent.
1897. §Hemming, G. W., K.C. 2 Earl's Court-square, S.W.
1899. §Hemsalech, G. A., D.Sc. The Owens College, Manchester.
1873. *Henderson, A. L. Westmoor Hall, Brimsdown, Middlesex.
1883. ‡Henderson, Mrs. A. L. Westmoor Hall, Brimsdown, Middlesex.
1901. ‡Henderson, Rev. Andrew, LL.D. Castle Head, Paisley.
1891. *Henderson, G. G., D.Sc., M.A., F.C.S., F.I.C., Professor of Chemistry in the Glasgow and West of Scotland Technical College. 204 George-street, Glasgow.
1892. ‡Henderson, John. 3 St. Catherine-place, Grange, Edinburgh.
1885. ‡Henderson, Sir William. Devanha House, Aberdeen.
1880. *Henderson, Rear-Admiral W. H., R.N. Royal Dockyard, Devonport.
1896. ‡Henderson, W. Saville, B.Sc. Beech Hill, Fairfield, Liverpool.
1873. *Henrici, Olaus M. F. E., Ph.D., F.R.S. (Pres. A, 1883; Council, 1883–89), Professor of Mechanics and Mathematics in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 34 Clarendon-road, Notting Hill, W.
1892. ‡Hepburn, David, M.D., F.R.S.E., Professor of Anatomy in University College, Cardiff.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Oakfield Cottage, Dartford Heath, Kent.
1890. ‡Hepper, J. 43 Cardigan-road, Headingley, Leeds.
1890. ‡Hepworth, Joseph. 25 Wellington-street, Leeds.
1892. *Herbertson, Andrew J., Ph.D., F.R.S.E., F.R.G.S. 9 Staverton-road, Oxford.

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Year of Election.

1902. †Herdman, G. W., B.Sc., Assoc.M.Inst.C.E. 2 Fyfield-road, Enfield.
1887. *Herdman, William A., D.Sc., F.R.S., F.R.S.E., F.L.S. (General Secretary, 1903– ; Pres. D, 1895; Council, 1894–1900; Local Sec. 1896), Professor of Natural History in the University of Liverpool. Croxteth Lodge, Sefton Park, Liverpool.
1893. *Herdman, Mrs. Croxteth Lodge, Sefton Park, Liverpool.
1875. ‡Hereford, The Right Rev. John Percival, D.D., LL.D., Lord Bishop of. The Palace, Hereford.
1891. †*Hern, S. South Cliff, Marine Parade, Penarth.*
1871. *Herschel, Alexander S., M.A., D.C.L., F.R.S., F.R.A.S., Honorary Professor of Physics and Experimental Philosophy in the University of Durham. Observatory House, Slough, Bucks.
1874. §Herschel, Colonel John, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.
1900. *Herschel, J. C. W. Littlemore, Oxford.
1900. †Herschel, Sir W. J., Bart. Littlemore, Oxford.
1903. *Hesketh, Charles H. B., M.A. The Rookery, North Meols, Southport.
1895. §Heaketh, James. Scarisbrick Avenue-buildings, 107 Lord-street, Southport.
1894. †Hewetson, G. H. (Local Sec. 1896). 39 Henley-road, Ipswich.
1894. ‡Hewins, W. A. S., M.A., F.S.S., Professor of Political Economy in King's College, London, W.C.
1896. §Hewitt, David Basil. Oakleigh, Northwich, Cheshire.
1903. §Hewitt, E. G. W. 87 Princess-road, Moss Side, Manchester.
1903. §Hewitt, John Theodore. 8 Montpellier-road, Twickenham.
1893. †Hewitt, Thomas P. Eccleston Park, Prescot, Lancashire.
1883. ‡Hewson, Thomas. Junior Constitutional Club, Piccadilly, W.
1882. ‡Heycock, Charles T., M.A., F.R.S. King's College, Cambridge.
1883. §Heyes, Rev. John Frederick, M.A., F.R.G.S. 90 Arkwright-street, Bolton.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1897. †Heys, Thomas. 130 King-street West, Toronto, Canada.
1901. *Heys, Z. John. Stonehouse, Barrhead, N.B.
1879. ‡Heywood, Sir A. Percival, Bart. Duffield Bank, Derby.
1886. ‡Heywood, Henry, J.P. Witla Court, near Cardiff.
1887. ‡Heywood, Robert. Mayfield, Victoria Park, Manchester.
1888. ‡Hichens, James Harvey, M.A. The School House, Wolverhampton.
1898. †Hicks, Henry B. 44 Pembroke-road, Clifton, Bristol.
1877. §Hicks, Professor W. M., M.A., D.Sc., F.R.S. (Pres. A, 1895), Principal of University College, Sheffield. Dunheved, Endcliffe-crescent, Sheffield.
1886. ‡Hicks, Mrs. W. M. Dunheved, Endcliffe-crescent, Sheffield.
1884. ‡Hickson, Joseph. 272 Mountain-street, Montreal, Canada.
1887. *Hickson, Sydney J., M.A., D.Sc., F.R.S. (Pres. D, 1903), Professor of Zoology in Owens College, Manchester.
1864. *Hiern, W. P., M.A., F.R.S. The Castle, Barnstaple.
1891. ‡Higgs, Henry, LL.B., F.S.S. (Pres. F, 1899). H.M. Treasury, Whitehall, S.W.
1885. *Hill, Alexander, M.A., M.D. Downing College, Cambridge.
1903. *Hill, Arthur W. King's College, Cambridge.
1881. *Hill, Rev. Edwin, M.A. The Rectory, Cockfield, Bury St. Edmunds.
1887. ‡Hill, G. H., M.Inst.C.E., F.G.S. Albert-chambers, Albert-square, Manchester.
1884. ‡Hill, Rev. James Edgar, M.A., B.D. 2488 St. Catherine-street, Montreal, Canada.

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Year of Election.

1886. ‡HILL, M. J. M., M.A., D.Sc., F.R.S., Professor of Pure Mathematics in University College, W.C.
1885. *Hill, Sidney. Langford House, Langford, Bristol.
1898. *Hill, Thomas Sidney. Langford House, Langford, Bristol.
1888. ‡Hill, William. Hitchin, Herts.
1876. ‡Hill, William H. Barlanark, Shettleston, N.B.
1885. *HILLHOUSE, WILLIAM, M.A., F.L.S., Professor of Botany in the University, Birmingham. 16 Duchess-road, Edgbaston, Birmingham.
1886. §Hillier, Rev. E. J. Cardington Vicarage, near Bedford.
1887. ‡Hilton, Edwin. Oak Bank, Fallowfield, Manchester.
1903. *Hilton, Harold. Bryn Teg-terrace, Bangor, North Wales.
1903. §HIND, Dr. WHEELTON, F.G.S. Roxeth House, Stoke-on-Trent.
1870. ‡HINDE, G. J., Ph.D., F.R.S., F.G.S. Ivythorn, Avondale-road, South Croydon, Surrey.
1883. *Hindle, James Henry. 8 Cobham-street, Accrington.
1888. *Hindmarsh, William Thomas, F.L.S. Alnbank, Alnwick.
1898. §Hinds, Henry. 57 Queen-street, Ramsgate.
1886. ‡Hingley, Sir Benjamin, Bart. Hatherton Lodge, Cradley, Worcestershire.
1881. ‡Hingston, J. T. Clifton, York.
1884. ‡HINGSTON, Sir WILLIAM HALES, M.D., D.C.L. 37 Union-avenue, Montreal, Canada.
1900. §Hinks, Arthur R., M.A. 10 Huntingdon-road, Cambridge.
1903. *Hinmers, Edward. Glentwood, South Down-drive, Hale, Cheshire.
1884. ‡Hirschfilder, C. A. Toronto, Canada.
1899. §Hobday, Henry. Hazelwood, Crabble Hill, Dover.
1887. *Hobson, Bernard, M.Sc., F.G.S. Tapton Elms, Sheffield.
1883. ‡Hobson, Mrs. Carey. 5 Beaumont-crescent, West Kensington, W.
1883. ‡Hobson, Rev. E. W. 55 Albert-road, Southport.
1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1876. ‡Hodges, Frederick W. Queen's College, Belfast.
1863. *HODGKIN, THOMAS, B.A., D.C.L. Benwell Dene, Newcastle-upon-Tyne.
1887. *Hodgkinson, Alexander, M.B., B.Sc., Lecturer on Laryngology at Owens College, Manchester. 18 St. John-street, Manchester.
1896. ‡Hodgkinson, Arnold. 22 Park-road, Southport.
1880. §Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., F.G.S., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 18 Glenluce-road, Blackheath, S.E.
1884. ‡Hodgson, Jonathan. Montreal, Canada.
1863. ‡Hodgson R. W. 7 Sandhill, Newcastle-upon-Tyne.
1898. ‡Hodgson, T. V. Municipal Museum and Art Gallery, Plymouth.
1896. ‡Hodgson, Dr. William, J.P. Helensville, Crewe.
1894. ‡Hogg, A. F., M.A. 13 Victoria-road, Darlington.
1894. ‡Holah, Ernest. 5 Crown-court, Cheapside, E.C.
1883. ‡Holden, James. 12 Park-avenue, Southport.
1883. ‡Holden, John J. 73 Albert-road, Southport.
1884. ‡Holden, Mrs. Mary E. Dunham Ladies' College, Quebec, Canada.
1887. *Holder, Henry William, M.A. Sheet, near Petersfield.
1896. ‡Holder, Thomas. 2 Tithebarn-street, Liverpool.
1900. §HOLDICH, Colonel Sir THOMAS H., R.E., K.C.B., K.C.I.E., F.R.G.S. (Pres. E, 1902). 23 Lansdowne-crescent, W.
1887. *Holdsworth, C. J. Sunnyside, Wilmslow, Cheshire.
1891. ‡Holgate, Benjamin, F.G.S. The Briers, North Park Avenue, Roundbay, Leeds.
1903. §Holland, J. L., B.A. 19 Tollington-place, N.
1896. ‡Holland, Mrs. Lowfields House, Hooton, Cheshire.
1898. ‡Holland, Thomas H., F.G.S. Geological Survey Office, Calcutta.

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Year of Election.

1889. ‡Holländer, Bernard, M.D. King's College, Strand, W.C.
1886. ‡Holliday, J. R. 101 Harborne-road, Birmingham.
1883. ‡Hollingsworth, Dr. T. S. Elford Lodge, Spring Grove, Isleworth.
1883. *Holmes, Mrs. Basil. 5 Freeland-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. 24 Aberdare-gardens, West Hampstead, N.W.
1892. ‡Holmes, Matthew. Netherby, Lenzie, Scotland.
1882. *Holmes, Thomas Vincent, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1903. *Holt, Alfred, jun., J.P. Crofton, Aigburth, Liverpool.
1896. ‡Holt, William Henry. 11 Ashville-road, Birkenhead.
1897. ‡Holterman, R. F. Brantford, Ontario, Canada.
1875. *Hood, John. Chesterton, Cirencester.
1847. ‡Hooker, Sir Joseph Dalton, G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. (President, 1868; Pres. E, 1881; Council 1866–67). The Camp, Sunningdale, Berkshire.
1892. ‡Hooker, Reginald H., M.A. 3 Gray's Inn-place, W.C.
1865. *Hooper, John P. Deepdene, Streatham Common, S.W.
1877. *Hooper, Rev. Samuel F., M.A. Lydlinch Rectory, Sturminster Newton, Dorset.
1901. *Hopkinson, Bertram, M.A. Holmwood, Wimbledon.
1884. *Hopkinson, Charles (Local Sec. 1887). The Limes, Didsbury, near Manchester.
1882. *Hopkinson, Edward, M.A., D.Sc. Oakleigh, Timperley, Cheshire.
1871. *Hopkinson, John, Assoc.M.Inst.C.E., F.L.S., F.G.S., F.R.Met.Soc. 84 New Bond-street, W.; and Weetwood, Watford.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
1891. ‡Horder, T. Garrett. 10 Windsor-place, Cardiff.
1898. *Hornby, R., M.A. Haileybury College, Hertford.
1885. ‡Horne, John, LL.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1901). Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1903. §Horne, William, F.G.S. Leyburn, Yorkshire.
1902. §Horner, John. Chelsea, Antrim-road, Belfast.
1875. *Horniman, F. J., M.P., F.R.G.S., F.L.S. Falmouth House, 20 Hyde Park-terrace, W.
1884. *Horsfall, Richard. Stoodley House, Halifax.
1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.
1893. *Horsley, Sir Victor A. H., B.Sc., F.R.S., F.R.C.S. (Council, 1893–98.) 25 Cavendish-square, W.
1884. *Hotblack, G. S. Brundall, Norwich.
1899. ‡Hotblack, J. T. 45 Newmarket-road, Norwich.
1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.
1896. *Hough, S. S., F.R.S. Royal Observatory, Cape Town.
1886. ‡Houghton, F. T. S., M.A., F.G.S. 188 Hagley-road, Edgbaston, Birmingham.
1887. ‡Houldsworth, Sir W. H., Bart., M.P. 35 Grosvenor-place, S.W.
1896. ‡Hoult, J. South Castle-street, Liverpool.
1884. ‡Houston, William. Legislative Library, Toronto, Canada.
1883. *Hovenden, Frederick, F.L.S., F.G.S. Glenlea, Thurlow Park-road, West Dulwich, Surrey, S.E.
1893. ‡Howard, F. T., M.A., F.G.S. The Cottage, Poynton, Stockport.
1883. ‡Howard, James Fielden, M.D., M.R.C.S. Sandycroft, Shaw.
1887. *Howard, S. S. 58 Albemarle-road, Beckenham, Kent.
1899. §Howard-Hayward, H. 16 Blakesley-avenue, Ealing, W.
1901. §Howarth, E. Public Museum, Weston Park, Sheffield.
1903. *Howarth, James H., F.G.S. Somerslev, Rawson-avenue, Halifax.
1886. ‡Howatt, David. 3 Birmingham-road, Dudley.
1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.

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Year of Election.

1899. ‡Howden, Ian D. C. 6 Cambridge-terrace, Dover.
1899. ‡Howden, Robert, M.B., Professor of Anatomy in the University of Durham College of Medicine. Newcastle-upon-Tyne.
1857. ‡Howell, Henry H., F.G.S. 13 Cobden-crescent, Edinburgh.
1898. ‡Howell, J. H. 104 Pembroke-road, Clifton, Bristol.
1891. ‡Howell, Rev. William Charles, M.A. Holy Trinity Parsonage, High Cross, Tottenham, Middlesex.
1886. ‡Howes, G. B., LL.D., D.Sc., F.R.S., F.L.S. (Pres. D, 1902; Council, 1902–), Professor of Zoology in the Royal College of Science, South Kensington, S.W.
1901. ‡Howie, Robert Y. 3 Greenlaw-avenue, Paisley.
1884. ‡Howland, Edward P., M.D. 211 41½-street, Washington, U.S.A.
1884. ‡Howland, Oliver Aiken. Toronto, Canada.
1865. *Howlett, Rev. Frederick, F.R.A.S. 7 Prince's-buildings, Clifton, Bristol.
1863. ‡Howorth, Sir H. H., K.C.I.E., D.C.L., F.R.S., F.S.A. 30 Collingham-place, Cromwell-road, S.W.
1883. ‡Howorth, John, J.P. Springbank, Burnley, Lancashire.
1883. ‡Hoyle, James. Blackburn.
1887. §Hoyle, William E., M.A. Owens College, Manchester.
1903. §Hübner, Julius. 24 Delaney's-road, Crumpsall, Manchester.
1888. ‡Hudd, Alfred E., F.S.A. Clinton House, Pembroke-road, Clifton, Bristol.
1898. §Hudleston, W. H., M.A., F.R.S., F.G.S. (Pres. C, 1898). 8 Stanhope-gardens, S.W.
1902. *Hudson, R. W. H. T., M.A. St. John's College, Cambridge.
1867. *Hudson, William H. H., M.A., Professor of Mathematics in King's College, London. 15 Altenberg-gardens, Clapham Common, S.W.
1858. *Huggins, Sir William, K.C.B., D.C.L. Oxon., LL.D. Camb., Pres.R.S., F.R.A.S. (President, 1891; Council, 1868–74, 1876–84). 90 Upper Tulse-hill, S.W.
1887. ‡Hughes, E. G. 4 Roman-place, Higher Broughton, Manchester.
1883. ‡Hughes, Miss E. P. Cambridge Teachers' College, Cambridge.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.
1887. ‡Hughes, John Taylor. Thorleymoor, Ashley-road, Altrincham.
1896. ‡Hughes, John W. New Heys, Allerton, Liverpool.
1891. ‡Hughes, Thomas, F.C.S. 31 Loudoun-square, Cardiff.
1868. §Hughes, T. M'K., M.A., F.R.S., F.G.S., Woodwardian Professor of Geology in the University of Cambridge. (Council, 1879–86.) Ravensworth, Brooklands-avenue, Cambridge.
1891. ‡Hughes, Rev. W. Hawker. Jesus College, Oxford.
1903. §Hulton, Campbell G. Palace Hotel, Southport.
1897. ‡Hume, J. G., M.A., Ph.D. 650 Church-street, Toronto, Canada.
1901. §Hume, John H. Toronto, Canada; and 63 Bridgegate, Irvine.
1890. ‡Humphrey, Frank W. 63 Prince's-gate, S.W.
1878. ‡Humphreys, H. Castle-square, Carnarvon.
1880. ‡Humphreys, Noel A., F.S.S. Ravenhurst, Hook, Kingston-on-Thames.
1877. *Hunt, Arthur Roope, M.A., F.G.S. Southwood, Torquay.
1891. *Hunt, Cecil Arthur. Southwood, Torquay.
1886. ‡*Hunt, Charles. The Gas Works, Windsor-street, Birmingham.*
1891. ‡Hunt, D. de Vere, M.D. Aubrey House, Cathedral-road, Cardiff.
1875. *Hunt, William. North Cote, Westbury-on-Trym, Bristol.
1881. ‡Hunter, F. W. Newbottle, Fence Houses, Co. Durham.
1889. ‡Hunter, Mrs. F. W. Newbottle, Fence Houses, Co. Durham.

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Year of Election.

1901. ‡Hunter, G. M., Assoc.M.Inst.C.E. Newyards, Maybole, N.B.
1881. ‡Hunter, Rev. John. University-gardens, Glasgow.
1901. *Hunter, William. Evirallan, Stirling.
1879. ‡Huntington, A. K., F.C.S., Professor of Metallurgy in King's College, W.C.
1885. ‡Huntly, The Most Hon. the Marquess of. Aboyne Castle, Aberdeenshire.
1868. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1898. ‡Hurle, J. Cooke. Southfield House, Brislington, Bristol.
1903. §Hurst, Charles C., F.L.S. Burbage, Hinckley.
1882. *Hurst, Walter, B.Sc. Kirkgate, Tadcaster, Yorkshire.
1861 *Hurst, William John. Drumaness, Ballynahinch, Co. Down, Ireland.
1894. *Hutchinson, A. Pembroke College, Cambridge.
1903. §Hutchinson, Rev. H. N. 94 Fellows-road, N.W.
1894. Hutton, Crompton. Harescombe Grange, Stroud, Gloucestershire.
*Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, N.W.
1887. *Hutton, J. Arthur. The Woodlands, Alderley Edge, Cheshire.
1901. *Hutton, R. S., M.Sc. The Owens College, Manchester.
1883. ‡Hyde, George H. 23 Arbour-street, Southport.
1871. *Hyett, Francis A. Painswick House, Painswick, Stroud, Gloucestershire.
1900. *Hyndman, H. H. Francis. Physical Laboratory, Leiden, Netherlands.
1902. ‡Hyndman, Hugh. Crosshill, Windsor-avenue, Belfast.

1883. §Idris, T. H. W. 110 Pratt-street, Camden Town, N.W.
Ihne, William, Ph.D. Heidelberg.
1884. *Iles, George. 5 Brunswick-street, Montreal, Canada.
1885. ‡im Thurn, Everard F., C.B., C.M.G. Colombo, Ceylon.
1888. *Ince, Surgeon-Lieut.-Col. John, M.D. Montague House, Swanley, Kent.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1893. ‡*Ingle, Herbert. Pool, Leeds.*
1901. ‡Inglis, John, LL.D. 4 Prince's-terrace, Dowanhill, Glasgow.
1891. ‡Ingram, Lieut.-Colonel C. W. Bradford-place, Penarth.
1852. ‡Ingram, J. K., LL.D., M.R.I.A., Senior Lecturer in the University of Dublin. 2 Wellington-road, Dublin.
1885. ‡Ingram, William, M.A. Gamrie, Banff.
1898. ‡Inskip, James. Clifton Park, Clifton, Bristol.
1901. *Ionides, Stephen A. 23 Second-avenue, Hove, Brighton.
1892. ‡Irvine, James. Devonshire-road, Birkenhead.
1882. §Irving, Rev. A., B.A., D.Sc. Hockerill Vicarage, Bishop's Stortford, Herts.
1903. §Irving, W. B. 27 Park-road, Southport.
1903. §Isherwood, Thomas, M.A., LL.D., F.R.S.E. 1 Cambridge-road, Southport.

1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1884. ‡Jack, Peter. People's Bank, Halifax, Nova Scotia, Canada.
1876. *Jack, William, LL.D., Professor of Mathematics in the University of Glasgow. 10 The College, Glasgow.
1901. §Jacks, William, LL.D. Crosslet, Dumbartonshire.
1883. *Jackson, Professor A. H., B.Sc. 349 Collins-street, Melbourne, Australia.

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Year of Election.

1903. §Jackson, C. S. 98 Herbert-road, Woolwich, S.E.
1874. *Jackson, Frederick Arthur. Penalva Ranche, Millarville, Alberta, Calgary, N.W.T., Canada.
1883. *Jackson, F. J. 35 Leyland-road, Southport.
1883. †Jackson, Mrs. F. J. 35 Leyland-road, Southport.
1899. ‡Jackson, Geoffrey A. 31 Harrington-gardens, Kensington, S.W.
1866. ‡Jackson, H. W., F.R.A.S. 67 Upgate, Louth, Lincolnshire.
1897. §Jackson, James, F.R.Met.Soc. The Avenue, Girvan, N.B.
1898. *Jackson, Sir John. 51 Victoria-street, S.W.
1869. §Jackson, Moses, J.P. The Orchards, Whitchurch, Hants.
1887. §Jacobson, Nathaniel. Olive Mount, Cheetham Hill-road, Manchester.
1874. *Jaffe, John. Villa Jaffe, 38 Prom. des Anglais, Nice, France.
1891. ‡James, Arthur P. Grove House, Park-grove, Cardiff.
1891. *James, Charles Henry, J.P. 64 Park-place, Cardiff.
1891. *James, Charles Russell. 6 New-court, Lincoln's Inn, W.C.
1860. ‡James, Edward H. Woodside, Plymouth.
1886. ‡James, Frank. Portland House, Aldridge, near Walsall.
1891. ‡James, Ivor. University College, Cardiff.
1891. ‡James, J. R., L.R.C.P. 158 Cowbridge-road, Canton, Cardiff.
1896. ‡James, O. S. 192 Jarvis-street, Toronto, Canada.
1858. ‡James, William C. Woodside, Plymouth.
1896. *Jameson, H. Lyster, M.A., Ph.D. Technical College, Derby.
1884. ‡Jameson, W. C. 48 Baker-street, Portman-square, W.
1881. ‡Jamieson, Andrew, Principal of the College of Science and Arts, Glasgow.
1885. ‡Jamieson, Thomas. 173 Union-street, Aberdeen.
1859. *Jamieson, Thomas F., LL.D., F.G.S. Ellon, Aberdeenshire.
1889. *Japp, F. R., M.A., Ph.D., LL.D., F.R.S. (Pres. B, 1898), Professor of Chemistry in the University of Aberdeen.
1896. *Jarmay, Gustav. Hartford Lodge, Hartford, Cheshire.
1903. §Jarratt, J. Ernest. (Local Sec. 1903.) 10 Cambridge-road, Southport.
1870. ‡Jarrold, John James. London-street, Norwich.
1891. ‡Jefferies, Henry. Plas Newydd, Park-road, Penarth.
1897. ‡Jeffrey, E. C., B.A. The University, Toronto, Canada.
1867. ‡Jeffreys, Howel, M.A. 61 Bedford-gardens, Kensington, W.
1894. ‡Jelly, Dr. W. Aveleanas, 11, Valencia, Spain.
1891. §Jenkins, Henry C., Assoc.M.Inst.C.E., F.C.S. Royal College of Science, South Kensington, S.W.
1873. ‡Jenkins, Major-General J. J. 16 St. James's-square, S.W.
1880. *Jenkins, Sir John Jones. The Grange, Swansea.
1899. §Jenkins, Colonel T. M. Glan Tivy, Westwood-road, Southampton.
1903. §Jenkinson, J. W. The Museum, Oxford.
1852. ‡Jennings, Francis M., M.R.I.A. Brown-street, Cork.
1893. §Jennings, G. E. Glen Helen, Narborough-road, Leicester.
1897. ‡Jennings, W. T., M.Inst.CE. Molson's Bank Buildings, Toronto, Canada.
1899. ‡Jepson, Thomas. Evington, Northumberland-street, Higher Broughton, Manchester.
1887. ‡Jervis-Smith, Rev. F. J., M.A., F.R.S. Trinity College, Oxford.
Jessop, William. Overton Hall, Ashover, Chesterfield.
1889. ‡Jevons, F. B., M.A. The Castle, Durham.
1900. *Jevons, H. Stanley. 19 Chesterfield-gardens, Hampstead, N.W.
1884. ‡Jewell, Lieutenant Theo. F. Torpedo Station, Newport, Rhode Island, U.S.A.
1884. ‡Johns, Thomas W. Yarmouth, Nova Scotia, Canada.

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Year of Election.

1884. ‡JOHNSON, ALEXANDER, M.A., LL.D., Professor of Mathematics in McGill University, Montreal. 5 Prince of Wales-terrace, Montreal, Canada.
1883. ‡Johnson, Miss Alice. Llandaff House, Cambridge.
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1888. ‡Johnson, J. G. Southwood Court, Highgate, N.
1881. ‡Johnson, Sir Samuel George. Municipal Offices, Nottingham.
1890. *JOHNSON, THOMAS, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.
1902. *Johnson, Rev. W., B.A., B.Sc. Archbishop Holgate's Grammar School, York.
1898. *Johnson, W. Claude, M.Inst.C.E. The Dignaries, Blackheath, S.E.
1887. ‡Johnson, W. H. Woodleigh, Altrincham, Cheshire.
1883. ‡Johnson, W. H. F. Llandaff House, Cambridge.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham, Cheshire.
1899. ‡Johnston, Colonel Duncan A., C.B., R.E. Ordnance Survey, Southampton.
1883. ‡JOHNSTON, Sir H. H., G.C.M.G., K.C.B., F.R.G.S. Queen Anne's-mansions, S.W.
1884. ‡Johnston, John L. 27 St. Peter-street, Montreal, Canada.
1883 ‡Johnston, Thomas. Broomsleigh, Seal, Sevenoaks.
1884. ‡Johnston, Walter R. Fort Qu'Appelle, N.W. Territory, Canada.
1884. *Johnston, W. H. County Offices, Preston, Lancashire.
1885. ‡JOHNSTON-LAVIS, H. J., M.D., F.G.S. Beaulieu, Alpes Maritimes, France.
1886. ‡Johnstone, G. H. Northampton-street, Birmingham.
1871. ‡JOLLY, WILLIAM, F.R.S.E., F.G.S. Blantyre Lodge, Blantyre, N.B.
1888. ‡*Jolly, W. C. Home Lea, Lansdowne, Bath.*
1896. *JOLY, C. J., M.A. The Observatory, Dunsink, Co. Dublin.
1888. ‡JOLY, JOHN, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Mineralogy in the University of Dublin.
1898. ‡Jones, Sir Alfred L., K.C.M.G. Care of Messrs. Elder, Dempster, & Co., Liverpool.
1887. ‡Jones, D. E., B.Sc., H.M. Inspector of Schools. Science and Art Department, South Kensington, S.W.
1890. §JONES, Rev. EDWARD, F.G.S. Primrose Cottage, Embsay, Skipton.
1896. ‡Jones, E. Taylor, D.Sc. University College, Bangor.
1891. ‡Jones, Dr. Evan. Ty-Mawr, Aberdare.
1903. §Jones, Evan. Ty-Mawr, Aberdare.
1887. ‡Jones, Francis, F.R.S.E., F.C.S. Beaufort House, Alexandra Park, Manchester.
1891. *JONES, Rev. G. HARTWELL, M.A. Nutfield Rectory, Redhill, Surrey.
1883. *Jones, George Oliver, M.A. Inchyra House, 21 Cambridge-road, Waterloo, Liverpool.
1903. *Jones, H. O. Clare College, Cambridge.
1895. ‡Jones, Harry. Engineer's Office, Great Eastern Railway, Ipswich.
1877. ‡Jones, Henry C., F.C.S. Royal College of Science, South Kensington, S.W.
1901. §Jones, R. E., J.P. Oakley Grange, Shrewsbury.
1902. §Jones, R. M., M.A. Royal Academical Institution, Belfast.
1873. ‡Jones, Theodore B. 1 Finsbury-circus, E.C.
1880. ‡Jones, Thomas. 15 Gower-street, Swansea.
1860. ‡JONES, THOMAS RUPERT, F.R.S., F.G.S. (Pres. C, 1891). 17 Parson's Green, Fulham, S.W.
1896. ‡Jones, W. Hope Bank, Lancaster-road, Pendleton, Manchester.

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Year of Election.

1883. ‡Jones, William. Elsinore, Birkdale, Southport.
1875. *Jose, J. E. 49 Whitechapel, Liverpool.
1884. ‡Joseph, J. H. 738 Dorchester-street, Montreal, Canada.
1891. ‡Jotham, F. H. Penarth.
1891. ‡Jotham, T. W. Penylan, Cardiff.
1879. ‡Jowitt, A. Scotia Works, Sheffield.
1890. ‡Jowitt, Benson R. Elmhurst, Newton-road, Leeds.
1872. ‡Joy, Algernon. Junior United Service Club, St. James's, S.W.
1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.
1886. ‡Joyce, The Hon. Mrs. St. John's Croft, Winchester.
1891. ‡Joynes, John J. Great Western Colliery, near Coleford, Gloucestershire.
1870. ‡JUDD, JOHN WESLEY, C.B., LL.D., F.R.S., F.G.S. (Pres. C, 1885; Council, 1886–92), Professor of Geology in the Royal College of Science, London. 22 Cumberland-road, Kew.
1903. §Julian, Henry Forbes. Redholme, Braddon's Hill-road, Torquay.
1894. §Julian, Mrs. Forbes. Redholme, Braddon's Hill-road, Torquay.
1883. ‡Justice, Philip Middleton. 14 Southampton-buildings, Chancery-lane, W.C.

1888. ‡Kapp, Gisbert, M.Inst.C.E., M.Inst.E.E. 3 Lindenallee, Westend, Berlin.
1884. ‡Keefer, Samuel. Brockville, Ontario, Canada.
1875. ‡Keeling, George William. Tuthill, Lydney.
1886. ‡Keen, Arthur, J.P. Sandyford, Augustus-road, Birmingham.
1894. ‡*Keightley, Rev. G. W. Great Stambridge Rectory, Rochford, Essex.*
1878. *Kelland, W. H. North Street, Exeter.
1884. ‡Kellogg, J. H., M.D. Battle Creek, Michigan, U.S.A.
1864. *Kelly, W. M., M.D. Ferring, near Worthing.
1902. *Kelly, William J., J.P. Oxford-street, Belfast.
1885. §KELTIE, J. SCOTT, LL.D., Sec. R.G.S., F.S.S. (Pres. E, 1897; Council, 1898–). 1 Savile-row, W.
1847. *KELVIN, The Right Hon. Lord, G.C.V.O., M.A., LL.D., D.C.L. F.R.S., F.R.S.E., F.R.A.S. (PRESIDENT, 1871; Pres. A, 1852, 1867, 1876, 1881, 1884; VICE-PRESIDENT, 1904.) Netherhall, Largs, Ayrshire.
1877. *Kelvin, Lady. Netherhall, Largs, Ayrshire.
1887. ‡Kemp, Harry. 55 Wilbraham-road, Chorlton-cum-Hardy, Manchester.
1898. *Kemp, John T., M.A. 4 Cotham-grove, Bristol.
1884. ‡Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.
1890. ‡Kempson, Augustus. Kildare, 17 Arundel-road, Eastbourne.
1891. §KENDALL, PERCY F., F.G.S., Professor of Geology in Yorkshire College, Leeds.
1875. ‡KENNEDY, ALEXANDER B. W., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1894). 1 Queen Anne-street, Cavendish-square, W.
1897. §Kennedy, George, M.A., LL.D. Crown Lands Department, Toronto, Canada.
1884. ‡Kennedy, George T., M.A., F.G.S., Professor of Chemistry and Geology in King's College, Windsor, Nova Scotia, Canada.
1876. ‡Kennedy, Hugh. 20 Mirkland-street, Glasgow.
1884. ‡Kennedy, John. 113 University-street, Montreal, Canada.
1884. ‡Kennedy, William. Hamilton, Ontario, Canada.
1886. ‡Kenrick, George Hamilton. Whetstone, Somerset-road, Edgbaston, Birmingham.

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Year of Election.

1893. §KENT, A. F. STANLEY, M.A., F.L.S., F.G.S., Professor of Physiology in University College, Bristol.
1901. §Kent, G. 16 Premier-road, Nottingham.
1886. §KENWARD, JAMES, F.S.A. 43 Streatham High-road, S.W.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1881. ‡KERMODE, PHILIP M. C. Claughbane, Ramsey, Isle of Man.
1884. ‡Kerr, James, M.D. Winnipeg, Canada.
1883. ‡KERR, REV. JOHN, LL.D., F.R.S. Free Church Training College, 113 Hill-street, Glasgow.
1901. ‡Kerr, John G., LL.D. 15 India-street, Glasgow.
1892. ‡KERR, J. GRAHAM, M.A., Professor of Natural History in the University, Glasgow.
1889. ‡Kerry, W. H. R. The Sycamores, Windermere.
1887. ‡Kershaw, James. Holly House, Bury New-road, Manchester.
1869. *Kesselmeyer, Charles Augustus. Rose Villa, Vale-road, Bowdon, Cheshire.
1869. *Kesselmeyer, William Johannes. Elysée Villa, Manchester-road, Altrincham, Cheshire.
1903. §Kewley, James. King William's College, Isle of Man.
1883. *Keynes, J. N., M.A., D.Sc., F.S.S. 6 Harvey-road, Cambridge.
1902. §Kidd, George. Dunmurry, Co. Antrim.
1876. ‡Kidston, J. B. 50 West Regent-street, Glasgow.
1886. §KIDSTON, ROBERT, F.R.S., F.R.S.E., F.G.S. 12 Clarendon-place, Stirling.
1897. ‡Kiekelly, Dr. John, LL.D. 46 Upper Mount-street, Dublin.
1901. *Kiep, J. N. 4 Hughenden-drive, Kelvinside, Glasgow.
1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.
1896. *Killey, George Deane. Bentuther, 11 Victoria-road, Waterloo, Liverpool.
1890. §KIMMINS, C. W., M.A., D.Sc. Bermondsey Settlement Lodge, Farncombe-street, S.E.
1878. ‡Kinahan, Sir Edward Hudson, Bart. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A. Dublin.
1875. *KINCH, EDWARD, F.C.S. Royal Agricultural College, Cirencester.
1888. ‡King, Austin J. Winsley Hill, Limpley Stoke, Bath.
1888. *King, E. Powell. Wainsford, Lymington, Hants.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1890. ‡KING, Sir GEORGE, K.C.I.E., F.R.S. (Pres. K, 1899). Care of Messrs. Grindlay & Co., 55 Parliament-street, S.W.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1883. *King, John Godwin. Stonelands, West Hoathly.
1870. ‡King, John Thomson. 4 Clayton-square, Liverpool.
1883. *King, Joseph. Sandhouse, Witley, Godalming.
1860. *King, Mervyn Kersteman. Merchants' Hall, Bristol.
1875. *King, Percy L. 2 Worcester-avenue, Clifton, Bristol.
1901. ‡King, Robert. Levernholme, Nitshill, Glasgow.
1870. ‡King, William, M.Inst.C.E. 5 Beach Lawn, Waterloo, Liverpool.
1903. §Kingsford, H. S., B.A. Anthropological Institute, 3 Hanover-square, W.
1897. ‡Kingsmill, Nichol. Toronto, Canada.
1875. ‡KINGZETT, CHARLES T., F.C.S. Elmstead Knoll, Chislehurst.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1892. ‡Kinnear, The Hon. Lord, F.R.S.E. 2 Moray-place, Edinburgh.
1900. ‡KIPPING, Professor F. STANLEY, D.Sc., Ph.D., F.R.S. University College, Nottingham.

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Year of Election.

1899. *Kirby, Miss C. F. 74 Kensington Park-road, W.
1870. ‡Kitchener, Frank E. Newcastle, Staffordshire.
1904. §Kitson, Arthur. 209 Gloucester-terrace, Hyde Park, W.
1890. *Kitson, Sir James, Bart., M.P. Gledhow Hall, Leeds.
1901. §Kitto, Edward. The Observatory, Falmouth.
1886. ‡Klein, Rev. L. M. de Beaumont, D.Sc., F.L.S. 6 Devonshire-road, Liverpool.
1886. ‡Knight, J. McK., F.G.S. Bushwood, Wanstead, Essex.
1898. ‡Knocker, Sir E. Wollaston, K.C.B. (Local Sec. 1899). Castle Hill House, Dover.
1888. ‡Knott, Professor Cargill G., D.Sc., F.R.S.E. 42 Upper Gray-street, Edinburgh.
1887. *Knott, Herbert. Aingarth, Stalybridge, Cheshire.
1887. *Knott, John F. Oak Hill, Windermere.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1903. §Knowlson, J. F. 26 Part-street, Southport.
1897. ‡Knowlton, W. H. 38 King-street East, Toronto, Canada.
1876. ‡Knox, David N., M.A., M.B. 24 Elmbank-crescent, Glasgow.
1902. ‡Knox, R. Kyle, LL.D. 1 College-gardens, Belfast.
1875. *Knubley, Rev. E. P., M.A. Steeple Ashton Vicarage, Trowbridge
1883. ‡Knubley, Mrs. Steeple Ashton Vicarage, Trowbridge.
1892. ‡Kohn, Charles A., Ph.D. Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C.
1898. ‡Krauss, A. Hawthornden, Priory-road, Clifton, Bristol.
1890. *Krauss, John Samuel, B.A. Stonycroft, Knutsford-road, Wilmslow, Cheshire.
1901. ‡Kuenen, Professor J. P., Ph.D. University College, Dundee.
1888. *Kunz, G. F., M.A., Ph.D. Care of Messrs. Tiffany & Co., 11 Union-square, New York City, U.S.A.
1870. ‡Kynaston, Josiah W., F.C.S. 3 Oak-terrace, Beech-street, Liverpool.

1884. ‡Laflamme, Rev. Professor J. C. K. Laval University, Quebec.
1885. *Laing, J. Gerard. 5 Pump-court, Temple, E.C.
1897. ‡Laird, Professor G. J. Wesley College, Winnipeg, Canada.
1877. ‡Lake, W. C., M.D. Teignmouth.
1889. *Lamb, Edmund, M.A. Borden Wood, Liphook, Hants.
1887. ‡Lamb, Horace, M.A., F.R.S., Professor of Pure Mathematics in the Owens College, Manchester. 6 Wilbraham-road, Fallowfield, Manchester.
1887. ‡Lamb, James. Kenwood, Bowdon, Cheshire.
1896. ‡Lambert, Frederick Samuel. Balgowan, Newland, Lincoln.
1893. ‡Lambert, J. W., J.P. Lenton Firs, Nottingham.
1903. §Lambert, Joseph. 9 Westmoreland-road, Southport.
1884. ‡Lamborn, Robert H. Montreal, Canada.
1893. *Lamplugh, G. W., F.G.S. Geological Survey Office, 14 Hume-street, Dublin.
1890. ‡Lamport, Edward Parke. Greenfield Well, Lancaster.
1884. ‡*Lancaster, Alfred. Fern Bank, Burnley, Lancashire.*
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1886. ‡Lancaster, W. J., F.G.S. Colmore-row, Birmingham.
1883. ‡Lang, Rev. Gavin. Mayfield, Inverness.
1859. ‡Lang, Rev. John Marshall, D.D. The University, Aberdeen.
1898. *Lang, William H. 10 Jedburgh-gardens, Kelvinside, Glasgow.
1886. *Langley, J. N., M.A., D.Sc., F.R.S. (Pres. I, 1899), Professor of Physiology in the University of Cambridge. Trinity College, Cambridge.

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Year of Election.

1870. †Langton, Charles. Barkhill, Aigburth, Liverpool.
1865. †Lankester, E. Ray, M.A., LL.D., F.R.S. (Pres. D, 1883; Council 1889–90, 1894–95, 1900–02), Director of the Natural History Museum, Cromwell-road, S.W.
1880. *Lansdell, Rev. Henry, D.D., F.R.A.S., F.R.G.S. Morden College, Blackheath, London, S.E.
1884. §Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.
1878. †Lapper, E., M.D. 61 Harcourt-street, Dublin.
1885. †Lapworth, Charles, LL.D., F.R.S., F.G.S. (Pres. C, 1892), Professor of Geology and Physiography in the University, Birmingham. 48 Frederick-road, Edgbaston, Birmingham.
1887. †Larmor, Alexander. Craglands, Helen's Bay, Co. Down.
1881. †Larmor, Joseph, M.A., D.Sc., Sec.R.S. (Pres. A, 1900), Lucasian Professor of Mathematics in the University of Cambridge. St. John's College, Cambridge.
1883. §Lascelles, B. P., M.A. Longridge, Harrow.
1896. *Last, William J. South Kensington Museum, London, S.W.
1870. *Latham, Baldwin, M.Inst.C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1900. †Lauder, Alexander. University College, Bangor.
1870. †Laughton, John Knox, M.A., F.R.G.S. 5 Pepys-road, Wimbledon, Surrey.
1891. †Laurie, A. P. Heriot Watt College, Edinburgh.
1892. §Laurie, Malcolm, B.A., D.Sc., F.L.S., Professor of Zoology in St. Mungo's College, Glasgow.
1888. †Laurie, Colonel R. P., C.B. 79 Farringdon-street, E.C.
1883. †Laurie, Major-General. Oakfield, Nova Scotia, Canada.
1870. *Law, Channell. Ilsham Dene, Torquay.
1878. †Law, Henry, M.Inst.C.E. 9 Victoria-chambers, S.W.
1884. §Law, Robert, F.G.S. Fennyroyd Hall, Hipperholme, near Halifax, Yorkshire.
1870. †Lawrence, Edward. Aigburth, Liverpool.
1881. †Lawrence, Rev. F., B.A. The Vicarage, Westow, York.
1900. †Lawrence, W. Trevor, Ph.D. 57 Prince's-gate, S.W.
1889. §Laws, W. G., M.Inst.C.E. 95 Osborne-road, Newcastle-upon-Tyne.
1885. †Lawson, James. 8 Church-street, Huntly, N.B.
1888. §Layard, Miss Nina F. Rookwood, Ipswich.
1856. †Lea, Henry. 38 Bennett's-hill, Birmingham.
1883. *Leach, Charles Catterall. Seghill, Northumberland.
1875. †Leach, Colonel Sir G., K.C.B., R.E. 6 Wetherby-gardens, S.W.
1894. *Leahy, A. H., M.A., Professor of Mathematics in University College, Sheffield. 92 Ashdell-road, Sheffield.
1884. *Leahy, John White, J.P. South Hill, Killarney, Ireland.
1901. *Lean, George, B.Sc. 15 Park-terrace, Glasgow.
1884. †Learmont, Joseph B. 120 Mackay-street, Montreal, Canada.
1884. *Leavitt, Erasmus Darwin. 2 Central-square, Cambridgeport, Massachusetts, U.S.A.
1872. †Lebour, G. A., M.A., F.G.S., Professor of Geology in the Durham College of Science, Newcastle-on-Tyne.
1884. †Leckie, R. G. Springhill, Cumberland County, Nova Scotia, Canada.
1895. *Ledger, Rev. Edmund. Protea, Doods-road, Reigate.
1898. †Lee, Arthur, J.P. (Local Sec. 1898). 10 Berkeley-square, Clifton, Bristol.
1896. §Lee, Rev. H. J. Barton. 35 Cross Park-terrace, Heavitree, Exeter.
1891. †*Lee, Mark. The Cedars, Llandaff-road, Cardiff.*
1894. *Lee, Mrs. W. Ashdown House, Forest Row, Sussex.

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Year of Election.

1884. *Leech, Sir Bosdin T. Oak Mount, Timperley, Cheshire.
1896. *Leech, Lady. Oak Mount, Timperley, Cheshire.
1892. *Lees, Charles H., D.Sc. 42 Lorne-grove, Fallowfield, Manchester.
1886. *Lees, Lawrence W. Old Ivy House, Tettenhall, Wolverhampton
1859. ‡Lees, William, M.A. 12 Morningside-place, Edinburgh.
1896. ‡Lees, William. 10 Norfolk-street, Manchester.
*Leese, Joseph. 3 Lord-street West, Southport.
1889. *Leeson, John Rudd, M.D., C.M., F.L.S., F.G.S. Clifden House, Twickenham, Middlesex.
1881. ‡Le Feuvre, J. E. (Local Sec. 1882). Southampton.
1872. ‡Lefevre, The Right Hon. G. Shaw, F.R.S. (Pres. F, 1879; Council 1878–80). 18 Bryanston-square, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1892. ‡Lehfeldt, Robert A. 28 South Molton-street, W.
1868. ‡Leicester, The Right Hon. the Earl of, K.G. Holkham, Norfolk.
1856. ‡Leigh, The Right Hon. Lord. Stoneleigh Abbey, Kenilworth.
1891. ‡Leigh, W. W. Treharris, R.S.O., Glamorganshire.
1903. §Leighton, G. R., M.D., F.R.S.E., Professor of Pathology in the Royal Veterinary College, Edinburgh.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1882. §Lemon, James, M.Inst.C.E., F.G.S. Lansdowne House, Southampton.
1903. *Lempfort, R. G. K., M.A. Meteorological Office, 63 Victoria-street, S.W.
1867. ‡Leng, Sir John, M.P. 'Advertiser' Office, Dundee.
1902. ‡Lennox, R. N. Rosebank, Hammersmith, W.
1878. ‡Lennon, Rev. Francis. The College, Maynooth, Ireland.
1887. *Leon, John T. Elmwood, Grove-road, Southsea.
1871. ‡Leonard, Hugh, M.R.I.A. 24 Mount Merrion-avenue, Blackrock, Co. Dublin.
1901. §Leonard, J. H. Paradise House, Stoke Newington, N.
1884. ‡Lesage, Louis. City Hall, Montreal, Canada.
1890. *Lester, Joseph Henry. Royal Exchange, Manchester.
1883. ‡Lester, Thomas. Fir Bank, Penrith.
1900. §Letts, Professor E. A., D.Sc., F.R.S.E. Queen's College, Belfast.
1894. ‡Leudesdorf, Charles. Pembroke College, Oxford.
1896. ‡Lever, W. H. Port Sunlight, Cheshire.
1887. *Levinstein, Ivan. Hawkesmoor, Fallowfield, Manchester.
1890. ‡Levy, J. H. 11 Abbeville-road, Clapham Park, S.W.
1893. *Lewes, Vivian B., F.C.S., Professor of Chemistry in the Royal Naval College, Greenwich, S.E.
1879. ‡Lewin, Colonel, F.R.G.S. Garden Corner House, Chelsea Embankment, S.W.
1870. ‡Lewis, Alfred Lionel. 54 Highbury-hill, N.
1891. ‡Lewis, D., J.P. 44 Park-place, Cardiff.
1891. §Lewis, Professor D. Morgan, M.A. University College, Aberystwyth.
1899. ‡Lewis, Professor E. P. University of California, Berkeley, U.S.A.
1897. ‡Lewis, Rev. J. Pitt, M.A. Rossin House, Toronto, Canada.
1899. ‡Lewis, Thomas. 9 Hubert-terrace, Dover.
1891. ‡Lewis, W. 22 Duke-street, Cardiff.
1891. ‡Lewis, W. Henry. Bryn Rhos, Llaniahen, Cardiff.
1884. *Lewis, Sir W. T., Bart. The Mardy, Aberdare.
1903. §Lewkowitsch, J. 71 Priory-road, N.W.
1878. ‡Lincolne, William. Ely, Cambridgeshire.
1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1904. §Link, Charles W. Eversley, Chichester-road, Croydon.
1898. ‡Lippincott, R. C. Cann. Over Court, Almondsbury, near Bristol.

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Year of Election.

1883. ‡*Lisle, H. Claud. Nantwich.*
1895. *Lister, The Right Hon. Lord, F.R.C.S., D.C.L., D.Sc., F.R.S. (President, 1896). 12 Park-crescent, Portland-place, W.
1888. ‡Lister, J. J., M.A., F.R.S. Leytonstone, Essex, N.E.
1861. *Liveing, G. D., M.A., F.R.S. (Pres. B, 1882; Council 1888–95; Local Sec. 1862), Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1876. *Liversidge, Archibald, M.A., F.R.S., F.C.S., F.G.S., F.R.G.S., Professor of Chemistry in the University of Sydney, N.S.W.
1902. §Llewellyn, Evan. Working Men's Institute and Hall, Blaenavon.
1880. ‡Llewelyn, Sir John T. D., Bart., M.P. Penllegare, Swansea.
1903. §Lloyd, Godfrey I. H. Grindleford, near Sheffield.
1886. ‡Lloyd, J. Henry. Ferndale, Carpenter-road, Edgbaston, Birmingham.
1891. *Lloyd, R. J., M.A., D.Litt., F.R.S.E 49A Grove-street, Liverpool.
1886. ‡Lloyd, Samuel. Farm, Sparkbrook, Birmingham.
1865. *Lloyd, Wilson, F.R.G.S. Park Lane House, Wednesbury.
1897. §Lloyd-Verney, J. H. 14 Hinde-street, Manchester-square, W.
1854. *Lobley, J. Logan, F.G.S. City of London College, Moorfields, E.C.
1892. §Loch, C. S., B.A. 15A Buckingham-street, W.C.
1867. *Locke, John. 144 St. Olaf's-road, Fulham, S.W.
1892. ‡Lockhart, Robert Arthur. 10 Polwarth-terrace, Edinburgh.
1863. ‡Lockyer, Sir J. Norman, K.C.B., LL.D., F.R.S. (President; Council 1871–76, 1901–02). 16 Penywern-road, S.W.
1902. *Lockyer, Lady. 16 Penywern-road, S.W.
1900. §Lockyer, W. J. S., Ph.D. 16 Penywern-road, South Kensington, S.W.
1886. *Lodge, Alfred, M.A., Professor of Pure Mathematics in the Royal Indian Civil Engineering College, Cooper's Hill. Englefield Green, Surrey.
1875. *Lodge, Sir Oliver J., D.Sc., LL.D., F.R.S. (Pres. A, 1891; Council 1891–97, 1899–1903), Principal of the University of Birmingham.
1894. *Lodge, Oliver W. F. 225 Hagley-road, Birmingham.
1889. ‡Logan, William. Langley Park, Durham.
1896. §Lomas, J., F.G.S. 13 Moss-grove, Birkenhead.
1899. §Loncq, Emile. 6 Rue de la Plaine, Laon, Aisne, France.
1902. ‡Londonderry, the Marquess of, K.G., H.M. Lieutenant of the City of Belfast. Londonderry House, Park-lane, W.
1903. §Long, Frederick. The Close, Norwich.
1876. ‡Long, H. A. Brisbane, Queensland.
1883. *Long, William. Thelwall Heys, near Warrington.
1883. ‡Long, Mrs. Thelwall Heys, near Warrington.
1883. ‡Long, Miss. Thelwall Heys, near Warrington.
1866. ‡Longdon, Frederick. Osmaston-road, Derby.
1901. ‡Longe, Francis D. The Alders, Marina, Lowestoft.
1898. *Longfield, Miss Gertrude. High Halstow Rectory, Rochester.
1901. *Longstaff, Frederick V., F.R.G.S. Clare College, Cambridge.
1875. *Longstaff, George Blundell, M.A., M.D., F.C.S., F.S.S. Highlands, Putney Heath, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon, Surrey.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, Surrey.
1899. *Longstaff, Tom G., B.A., F.R.Met.Soc. Ridgelands, Wimbledon, Surrey.
1883. *Longton, E. J., M.D. Brown House, Blawith, *viâ* Ulverston.
1894. ‡Lord, Edwin C. E., Ph.D. 247 Washington-street, Brooklyn, U.S.A.
1889. ‡Lord, Sir Riley. 75 Pilgrim-street, Newcastle-upon-Tyne.

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Year of Election.

1903. §Loton, John, M.A. 29 Manchester-road, Southport.
1897. ‡Loudon, James, LL.D., President of the University of Toronto, Canada.
1883. *Louis, D. A., F.C.S. 77 Shirland-gardens, W.
1896. §Louis, Henry, M.A., Professor of Mining, Durham College of Science, Newcastle-on-Tyne.
1887. *Love, A. E. H., M.A., D.Sc., F.R.S., Professor of Natural Philosophy in the University of Oxford. 34 St. Margaret's-road, Oxford.
1886. *Love, E. F. J., M.A. The University, Melbourne, Australia.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 33 Clanricarde-gardens, W.
1883. ‡Love, James Allen. 8 Eastbourne-road West, Southport.
1875. *Lovett, W. Jesse. Panton House, Panton-road, Hoole, Chester.
1889. ‡*Low, Charles W.* 84 *Westbourne-terrace, W.*
1885. §Lowdell, Sydney Poole. Baldwin's Hill, East Grinstead, Sussex.
1891. ‡Lowdon, John. St. Hilda's, Barry, Glamorgan.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1892. ‡Lowe, D. T. Heriot's Hospital, Edinburgh.
1886. *Lowe, John Landor, B.Sc., M.Inst.C.E. Spondon, Derbyshire.
1894. ‡Lowenthal, Miss Nellie. 60 New North-road, Huddersfield.
1903. *Lowry, T. Martin. 44 Blenheim-crescent, W.
1881. ‡Lubbock, Arthur Rolfe. High Elms, Farnborough, R.S.O., Kent.
1881. ‡Lubbock, John B. 14 Berkeley-street, W.
1870. ‡Lubbock, Montague, M.D. 19 Grosvenor-street, W.
1889. ‡Lucas, John. 1 Carlton-terrace, Low Fell, Gateshead.
1901. *Lucas, Keith. Greenhall, Forest Row, Sussex.
1878. ‡Lucas, Joseph. Tooting Graveney, S.W.
1889. ‡*Luckley, George. The Grove, Jesmond, Newcastle-upon-Tyne.*
1891. *Lucovich, Count A. Tyn-y-parc, Whitchurch, near Cardiff.
1881. ‡Luden, C. M. 4 Bootham-terrace, York.
1866. *Lund, Charles. Ilkley, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 32 Newport-road, Cardiff.
1892. ‡Lunn, Robert. Geological Survey Office, Sheriff Court House, Edinburgh.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1883. *Lupton, Arnold, M.Inst.C.E., F.G.S. 6 De Grey-road, Leeds.
1874. *Lupton, Sydney, M.A. (Local Sec. 1890). 102 Park-street, Grosvenor-square, W.
1900. ‡Lupton, William C. Bradford.
1864. *Lutley, John. Brockhampton Park, Worcester.
1898. §Luxmoore, Dr. C. M. University College, Reading.
1903. §Lyddon, Ernest H. Lisvane, near Cardiff.
1871. ‡Lyell, Sir Leonard, Bart., F.G.S. 48 Eaton-place, S.W.
1899. ‡Lyle, Professor Thomas R. The University, Melbourne.
1884. ‡Lyman, A. Clarence. 84 Victoria-street, Montreal, Canada.
1884. ‡Lyman, H. H. 74 McTavish-street, Montreal, Canada.
1874. ‡Lynam, James. Ballinasloe, Ireland.
1885. ‡Lyon, Alexander, jun. 52 Carden-place, Aberdeen.
1896. ‡Lyster, A. G. Dockyard, Coburg Dock, Liverpool.
1862. *Lyte, F. Maxwell, M.A., F.C.S. 60 Finborough-road, S.W.

1868. ‡Macalister, Alexander, M.A., M.D., F.R.S. (Pres. H, 1892; Council, 1901–), Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.
1878. ‡MacAlister, Donald, M.A., M.D., B.Sc. St. John's College, Cambridge.

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Year of Election.

1896. †*Macalister, R. A. S.* 2 *Gordon-street, W.C.*
1897. †McAllister, Samuel. 99 Wilcox-street, Toronto, Canada.
1896. §MACALLUM, Professor A. B., Ph.D. (Local Sec. 1897). 59 St. George-street, Toronto, Canada.
1879. §MacAndrew, James J., F.L.S. Lukesland, Ivybridge, South Devon.
1883. †MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, William. Westwood House, near Colchester.
1866. *M'Arthur, Alexander. 79 Holland-park, W.
1896. †McArthur, Charles. Villa Marina, New Brighton, Cheshire.
1884. †Macarthur, D. Winnipeg, Canada.
1896. *Macaulay, F. S., M.A. 19 Dewhurst-road, W.
1896. †MACBRIDE, Professor E. W., M.A. McGill University, Montreal, Canada.
1884. †McCabe, T., Chief Examiner of Patents. Patent Office, Ottawa, Canada.
1902. *Maccall, W. T., M.Sc. Dalton Hall, Victoria Park, Manchester.
1886. †MacCarthy, Rev. E. F. M., M.A. 93 Hagley-road, Birmingham.
1887. *McCarthy, James. Care of Sir Sherston Baker, Bart., 18 Cavendish-road, Regent's Park, N.W.
1884. *McCarthy, J. J., M.D. 83 Wellington-road, Dublin.
1891. *McCLEAN, FRANK, M.A., LL.D., F.R.S., M.Inst.C.E. Rusthall House, Tunbridge Wells.
1876. *M'CLELLAND, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1902. †McClelland, J. A., M.A., Professor of Physics in University College, Dublin.
1868. †M'CLINTOCK, Admiral Sir FRANCIS L., R.N., K.C.B., F.R.S., F.R.G.S. United Service Club, Pall Mall, S.W.
1878. *M'Comas, Henry. Pembroke House, Pembroke-road, Dublin.
1901. *MacConkey, Alfred. Jenner Institute of Preventive Medicine, Chelsea-gardens, S.W.
1901. †MacCormac, J. M., M.D. 31 Victoria-place, Belfast.
1892. *McCowan, John, M.A., D.Sc. Henderson-street, Bridge of Allan, N.B.
1892. †McCrae, George. 3 Dick-place, Edinburgh.
1901. †McCrae, John, Ph.D. 7 Kirklee-gardens, Glasgow.
1899. †McDiarmid, Jabez. The Elms, Stanmore, Middlesex.
1900. †MacDonald, J. R. 3 Lincoln's Inn-fields, W.C.
1890. *MacDonald, Mrs. J. R. 3 Lincoln's Inn-fields, W.C.
1886. †McDonald, John Allen. Hillsboro' House, Derby.
1884. †MacDonald, Kenneth. Town Hall, Inverness.
1884. *McDonald, Sir W. C. 891 Sherbrooke-street, Montreal, Canada.
1884. †MacDonnell, Mrs. F. H. 1433 St. Catherine-street, Montreal, Canada.
1884. †McDougall, John. 35 St. François Xavier-street, Montreal, Canada.
1897. †McEwen, William C. 9 South Charlotte-street, Edinburgh.
1902. §Macfadyen, Allan, M.D., B.Sc. Lister Institute of Preventive Medicine, Chelsea-gardens, S.W.
1881. †Macfarlane, Alexander, D.Sc., F.R.S.E., Professor of Physics in the University of Texas. Austin, Texas, U.S.A.
1885. †Macfarlane, J. M., D.Sc., F.R.S.E., Professor of Biology in the University of Pennsylvania, Lansdowne, Delaware Co., Pennsylvania, U.S.A.
1897. †McFarlane, Murray, M.D. 32 Carlton-street, Toronto, Canada.
1879. †Macfarlane, Walter, jun. 12 Lynedoch-crescent, Glasgow.
1901. †Macfee, John. Marguerite, Blackhall, Paisley.
1897. †McGaw, Thomas. Queen's Hotel, Toronto, Canada.
1888. †MacGeorge, James. 7 Stonor-road, Kensington, W.
1884. †MacGillivray, James. 42 Cathcart-street, Montreal, Canada.

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Year of Election.

1884. †MacGoun, Archibald, jun., B.A., B.C.L. Dunavon, Westmount, Montreal, Canada.
1884. *MacGregor, James Gordon, M.A., D.Sc., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh.
1885. †M'Gregor-Robertson, J., M.A., M.B. 26 Buckingham-terrace, Glasgow.
1902. §McIlroy, Archibald. Glenvale, Drumbo, Lisburn, Ireland.
1867. *McIntosh W. C., M.D., LL.D., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1885), Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.
1884. †McIntyre, John, M.D. Odiham, Hants.
1883. †Mack, Isaac A. Trinity-road, Bootle.
1884. §MacKay, A. H., B.Sc., LL.D., Superintendent of Education. Education Office, Halifax, Nova Scotia, Canada.
1885. §Mackay, John Yule, M.D., Professor of Anatomy in University College, Dundee.
1897. †McKay, T. W. G., M.D. Oshawa, Ontario, Canada.
1896. *McKechnie, Duncan. Eccleston Grange, Prescot.
1873. †McKendrick, John G., M.D., LL.D., F.R.S., F.R.S.E. (Pres. I, 1901; Council, 1903-), Professor of Physiology in the University of Glasgow. 2 Buckingham-terrace, Glasgow.
1897. †McKenzie, John J. 61 Madison-avenue, Toronto, Canada.
1884. †MacKenzie, Stephen, M.D. 18 Cavendish-square, W.
1884. †McKenzie, Thomas, B.A. School of Science, Toronto, Canada.
1901. *Mackenzie, Thomas Brown. Elenslee, Wilson-street, Motherwell.
1883. †Mackeson, Henry. Hythe, Kent.
1872. *Mackey, J. A. 175 Grange-road, S.E.
1867. †Mackie, Samuel Joseph. 17 Howley-place, W.
1901. §Mackie, William, M.D. 13 North-street, Elgin.
1884. †McKilligan, John B. 387 Main-street, Winnipeg, Canada.
1887. †Mackinder, H. J., M.A., F.R.G.S. (Pres. E, 1895). Christ Church, Oxford.
1891. †Mackintosh, A. C. 88 Plymouth-road, Penarth.
1872. *McLachlan, Robert, F.R.S., F.L.S. West View, Clarendon-road, Lewisham, S.E.
1896. †Maclagan, Miss Christian. Ravenscroft, Stirling.
1892. †Maclagan, Philip R. D. St. Catherine's, Liberton, Midlothian.
1892. †Maclagan, R. Craig, M.D., F.R.S.E. 5 Coates-crescent, Edinburgh.
1885. *M'Laren, The Hon. Lord, F.R.S.E., F.R.A.S. 46 Moray-place, Edinburgh.
1897. †MacLaren, J. F. 380 Victoria-street, Toronto, Canada.
1901. †Maclaren, J. Malcolm. 62 Sydney-street, South Kensington, S.W.
1873. †MacLaren, Walter S. B. Newington House, Edinburgh.
1897. †MacLaren, Rev. Wm., D.D. 57 St. George-street, Toronto, Canada.
1901. †Maclay, James. 3 Woodlands-terrace, Glasgow.
1901. §Maclay, William. Thornwood, Langside, Glasgow.
1901. §McLean, Angus, B.Sc. Ascog, Meikleriggs, Paisley.
1892. *Maclean, Magnus, M.A., D.Sc., F.R.S.E. (Local Sec. 1901), Professor of Electrical Engineering, Technical College, Glasgow.
1884. †McLennan, Frank. 317 Drummond-street, Montreal, Canada.
1884. †McLennan, Hugh. 317 Drummond-street, Montreal, Canada.
1884. †McLennan, John. Lancaster, Ontario, Canada.
1868. §McLeod, Herbert, F.R.S. (Pres. B, 1892; Council, 1885-90). 9 Coverdale, Richmond, Surrey.
1892. †Macleod, W. Bowman. 16 George-square, Edinburgh.

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Year of Election.

1883. *McMahon, Lieut.-General C. A., F.R.S., F.G.S. (Pres. C, 1902). 20 Nevern-square, South Kensington, S.W.
1883. ‡MacMahon, Major Percy A., R.A., D.Sc., F.R.S. (General Secretary, 1902– ; Pres. A, 1901; Council, 1898–1902). Queen Anne's-mansions, Westminster, S.W.
1878. *M'Master, George, M.A., J.P. Rathmines, Ireland.
1902. ‡McMordie, Robert J. Cabin Hill, Knock, Co. Down.
1884. ‡McMurrick, J. Playfair. University of Michigan, Ann Arbor, Michigan, U.S.A.
1867. ‡M'Neill, John. Balhousie House, Perth.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1887. ‡Maconochie, A. W. Care of Messrs. Maconochie Bros., Lowestoft.
1883. ‡Macpherson, J. 44 Frederick-street, Edinburgh.
1901. §MacRitchie, David. 4 Archibald-place, Edinburgh.
*Macrory, Edmund, M.A., K.C. 19 Pembridge-square, W.
1902. ‡McWeeney, E. J., M.D. 84 Stephen's-green, Dublin.
1902. §McWhirter, William. 9 Walworth-terrace, Glasgow.
1887. ‡Macy, Jesse. Grinnell, Iowa, U.S.A.
1883. ‡Madden, W. H. Marlborough College, Wilts.
1902. §Magill, R., M.A., Ph.D. The Manse, Maghera, Co. Derry.
1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *Magnus, Sir Philip, B.Sc. 16 Gloucester-terrace, Hyde Park, W.
1896. ‡Maguire, Thomas Philip. Eastfield, Lodge-lane, Liverpool.
1902. ‡Mahon, J. L. 2 May-street, Drumcondra, Dublin.
1878. ‡Mahony, W. A. 34 College-green, Dublin.
1887. ‡*Mainprice, W. S. Longcroft, Altrincham, Cheshire.*
1902. §Maitland, Miss Agnes C. Somerville College, Oxford.
1883. ‡Maitland, P. C. 136 Great Portland-street, W.
1899. ‡Makarius, Saleem. 'Al Mokattam,' Cairo.
1881. ‡*Malcolm, Lieut.-Colonel, R.E. 72 Nunthorpe-road, York.*
1874. ‡Malcolmson, A. B. Friends' Institute, Belfast.
1857. ‡Mallet, John William, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, Albemarle Co., U.S.A.
1896. *Manbré, Alexandre. 15 Alexandra-drive, Liverpool.
1897. ‡Mance, Sir H. C. 32 Earl's Court-square, S.W.
1887. ‡Manchester, The Right Rev. the Lord Bishop of, D.D. Bishop's Court, Manchester.
1903. §Manifold, C. C. 16 St. James's-square, S.W.
1870. ‡*Manifold, W. H., M.D. 45 Rodney-street, Liverpool.*
1901. ‡Mann, John, jun., M.A. 137 West George-street, Glasgow.
1888. ‡Mann, W. J. Rodney House, Trowbridge.
1894. ‡Manning, Percy, M.A., F.S.A. Watford, Herts.
1888. ‡Mansbergh, James, M.Inst.C.E., F.R.S., F.G.S. 5 Victoria-street, Westminster, S.W.
1891. ‡Manuel, James. 175 Newport-road, Cardiff.
1887. *March, Henry Colley, M.D., F.S.A. Portesham, Dorchester, Dorsetshire.
1902. *Marchant, Dr. E. W. University College, Liverpool.
1870. ‡Marcoartu, His Excellency Don Arturo de. Madrid.
1898. *Mardon, Heber. 2 Litfield-place, Clifton, Bristol.
1900 ‡Margerison, Samuel. Calverley Lodge, near Leeds.
1887. ‡*Margetson, J. Charles. The Rocks, Limpley, Stoke.*
1883. ‡Marginson, James Fleetwood. The Mount, Fleetwood, Lancashire.
1887. ‡*Markham, Christopher A., F.R.Met.Soc. Spratton, Northampton.*

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Year of Election.

1864. ‡MARKHAM, Sir CLEMENTS R., K.C.B., F.R.S., Pres.R.G.S., F.S.A. (Pres. E, 1879; Council 1893–96). 21 Eccleston-square, S.W.
1863. ‡Marley, John. Mining Office, Darlington.
1888. ‡Marling, W. J. Stanley Park, Stroud, Gloucestershire.
1888. ‡Marling, Lady. Stanley Park, Stroud, Gloucestershire.
1881. *MARR, J. E., M.A., F.R.S., F.G.S. (Pres. C, 1896; Council 1896–1902). St. John's College, Cambridge.
1903. §Marriott, William. Royal Meteorological Society, 70 Victoria-street, S.W.
1887. ‡*Marsden, Benjamin. Westleigh, Heaton Mersey, Manchester.*
1884. *Marsden, Samuel. 1015 North Leffingwell-avenue, St. Louis, Missouri, U.S.A.
1892. *Marsden-Smedley, J. B. Lea Green, Cromford, Derbyshire.
1883. *Marsh, Henry. 72 Wellington-street, Leeds.
1887. ‡Marsh, J. E., M.A. The Museum, Oxford.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1889. *MARSHALL, ALFRED, M.A., LL.D. (Pres. F, 1890), Professor of Political Economy in the University of Cambridge. Balliol Croft, Madingley-road, Cambridge.
1892. §Marshall, Hugh, D.Sc., F.R.S.E. 12 Lonsdale-terrace, Edinburgh.
1890. ‡Marshall, John. Derwent Island, Keswick.
1901. §Marshall, Robert. 97 Wellington-street, Glasgow.
1886. *MARSHALL, WILLIAM BAYLEY, M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1849. *MARSHALL, WILLIAM P., M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1865. ‡MARTEN, EDWARD BINDON. Pedmore, near Stourbridge.
1899. §Martin, Miss A. M. Park View, 32 Bayham-road, Sevenoaks.
1891. *Martin, Edward P., J.P. Dowlais, Glamorgan.
1887. **Martin, Rev. H. A. Grosvenor Club, Grosvenor-crescent, S.W.*
1884. §Martin, N. H., J.P., F.L.S. Ravenswood, Low Fell, Gateshead-on-Tyne.
1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Northdene, New Barnet, Herts.
1865. ‡Martineau, R. F. 18 Highfield-road, Edgbaston, Birmingham.
1883. ‡MARWICK, Sir J. D., LL.D., F.R.S.E. (Local Sec. 1871, 1876, 1901). Glasgow.
1891. ‡Marychurch, J. G. 46 Park-street, Cardiff.
1873. *MASHAM, Lord. Swinton Park, Swinton.
1847. ‡MASKELYNE, NEVIL STORY, M.A., D.Sc., F.R.S., F.G.S. (Council 1874–80). Basset Down House, Swindon.
1886. ‡Mason, Hon. J. E. Fiji.
1896. ‡Mason, Philip B., F.L.S., F.Z.S. Burton-on-Trent.
1893. *Mason, Thomas. Endersleigh, Alexandra Park, Nottingham.
1891. *Massey, William H., M.Inst.C.E. Twyford, R.S.O., Berkshire.
1885. ‡Masson, Orme, D.Sc., F.R.S. University of Melbourne, Victoria, Australia.
1898. ‡Masterman, A. T. University of St. Andrews, N.B.
1901. *Mather, G. R. Boxlea, Wellingborough.
1883. ‡Mather, Robert V. Birkdale Lodge, Birkdale, Southport.
1887. *Mather, Sir William, M.P., M.Inst.C.E. Salford Iron Works, Manchester.
1890. ‡*Mathers, J. S. 1 Hanover-square, Leeds.*
1865. ‡Mathews, C. E. Waterloo-street, Birmingham.
1898. ‡Mathews, E. R. Norris. Cotham-road, Cotham, Bristol.
1894. ‡MATHEWS, G. B., M.A., F.R.S. St. John's College, Cambridge.
1865. *Mathews, G. S. 32 Augustus-road, Edgbaston, Birmingham.

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Year of Election.

1889. ‡**Mathews**, John Hitchcock. 1 Queen's-gardens, Hyde Park, W.
1881. ‡**Mathwin**, Henry, B.A. 26 Oxford-road, Birkdale, Southport.
1883. ‡**Mathwin**, Mrs. H. 26 Oxford-road, Birkdale, Southport.
1902. ‡**Matley**, C. A. 90 St. Lawrence-road, Clontarf, Dublin.
1858. ‡**Matthews**, F. C. Mandre Works, Driffield, Yorkshire.
1899. ‡**Matthews**, William, C.M.G., M.Inst.C.E. 9 Victoria-street, S.W.
1893. ‡**Mavor**, Professor James, M.A., LL.D. University of Toronto, Canada.
1865. ***Maw**, George, F.L.S., F.G.S., F.S.A. Benthall, Kenley, Surrey.
1894. §**Maxim**, Sir Hiram S. 18 Queen's Gate-place, Kensington, S.W.
1903. §**Maxwell**, J. M. 37 Ash-street, Southport.
***Maxwell**, Robert Perceval. Finnebrogue, Downpatrick.
1883. §**May**, William, F.G.S. Northfield, St. Mary Cray, Kent.
1901. ***May**, W. Page, M.D., B.Sc. 9 Manchester-square, W.
1884. ***Maybury**, A. C., D.Sc. 8 Heathcote-street, W.C.
1878. ***Mayne**, Thomas. 33 Castle-street, Dublin.
1871. ‡**Meikle**, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §**Meiklejohn**, John W. S., M.D. 105 Holland-road, W.
1887. ‡**Meischke-Smith**, W. Rivala Lumpore, Salengore, Straits Settlements.
1881. ***Meldola**, Raphael, F.R.S., F.R.A.S., F.C.S., F.I.C. (Pres. B, 1895; Council 1892–99), Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, W.C.
1883. ‡**Mellis**, Rev. James. 23 Part-street, Southport.
1879. ***Melliah**, Henry. Hodsock Priory, Worksop.
1866. ‡**Mello**, Rev. J. M., M.A., F.G.S. Cliff Hill, Warwick.
1883. ‡**Mello**, Mrs. J. M. Cliff Hill, Warwick.
1896. §**Mellor**, G. H. Weston, Blundellsands, Liverpool.
1881. §**Melrose**, James. Clifton Croft, York.
1887. ‡**Melvill**, J. Cosmo, M.A. Kersal Cottage, Prestwich, Manchester.
1863. ‡**Melvin**, Alexander. 42 Buccleuch-place, Edinburgh.
1896. ‡**Menneer**, R. R. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1901. ‡**Mennell**, F. P. 8 Addison-road, W.
1862. ‡**Mennell**, Henry T. St. Dunstan's-buildings, Great Tower-street, E.C.
1879. ‡**Merivale**, John Herman, M.A. (Local Sec. 1889). Togston Hall, Acklington.
1899. ***Merrett**, William H. Hatherley, Grosvenor-road, Wallington, Surrey.
1880. ‡*Merry, Alfred S. Bryn Heulog, Sketty, near Swansea.*
1899. ‡**Merryweather**, J. C. 4 Whitehall-court, S.W.
1889. ***Merz**, John Theodore. The Quarries, Newcastle-upon-Tyne.
1863. ‡**Messent**, P. T. 4 Northumberland-terrace, Tynemouth.
1896. ‡**Metzler**, W. H., Professor of Mathematics in Syracuse University, Syracuse, New York, U.S.A.
1869. ‡**Miall**, Louis C., F.R.S., F.L.S., F.G.S. (Pres. D, 1897; Local Sec. 1890), Professor of Biology in the Yorkshire College, Leeds. Richmond-mount, Headingley, Leeds.
1903. §**Micklethwait**, Miss F. G. Queen's College, Galway.
1866. ‡*Middlemore, Thomas. Holloway Head, Birmingham.*
1865. ‡**Middlemore**, William. Edgbaston, Birmingham.
1881. ***Middlesbrough**, The Right Rev. Richard Lacy, D.D., Bishop of. Middlesbrough.
1893. ‡**Middleton**, A. 25 Lister-gate, Nottingham.
1881. ‡**Middleton**, R. Morton, F.L.S., F.Z.S. 46 Windsor-road, Ealing, W.

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Year of Election.

1894. *Miers, H. A., M.A., F.R.S., F.G.S., Professor of Mineralogy in the University of Oxford. Magdalen College, Oxford.
1889. ‡Milburn, John D. Queen-street, Newcastle-upon-Tyne.
1886. ‡Miles, Charles Albert. Buenos Ayres.
1881. ‡Miles, Morris (Local Sec. 1882). Warbourne, Hill-lane, Southampton.
1885. §Mill, Hugh Robert, D.Sc., LL.D., F.R.S.E., F.R.G.S. (Pres. E, 1901). 62 Camden-square, N.W.
1889. *Millar, Robert Cockburn. 30 York-place, Edinburgh.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1895. ‡Miller, Henry, M.Inst.C.E. Bosmere House, Norwich-road, Ipswich.
1888. ‡Miller, J. Bruce. Rubislaw Den North, Aberdeen.
1885. ‡Miller, John. 9 Rubislaw-terrace, Aberdeen.
1886. ‡Miller, Rev. John, B.D. The College, Weymouth.
1861. *Miller, Robert. Totteridge House, Hertfordshire, N.
1895. ‡Miller, Thomas, M.Inst.C.E. 9 Thoroughfare, Ipswich.
1884. ‡Miller, T. F., B.Ap.Sc. Napanee, Ontario, Canada.
1876. ‡Miller, Thomas Paterson. Cairns, Cambualang, N.B.
1897. ‡Miller, Willet G., Professor of Geology in Queen's University, Kingston, Ontario, Canada.
1902. ‡Millin, S. T. Sheridan Lodge, Helen's Bay, Co. Down.
1888. *Mills Edmund J., D.Sc., F.R.S., F.C.S. 11 Greenhill-road, Harrow.
1880. ‡Mills, Mansfeldt H., M.Inst.C.E., F.G.S. Sherwood Hall, Mansfield.
1902. §Mills, W. Sloan, M.A. Vine Cottage, Donaghmore, Newry.
1885. ‡Milne, Alexander D. 40 Albyn-place, Aberdeen.
1882. *Milne, John, F.R.S., F.G.S. Shide Hill House, Shide, Isle of Wight.
1903. *Milne, R. M. Royal Military Academy, Woolwich.
1885. ‡Milne, William. 40 Albyn-place, Aberdeen.
1898. *Milner, S. Roslington, D.Sc. University College, Sheffield.
1882. ‡Milnes, Alfred, M.A., F.S.S. 22A Goldhurst-terrace, South Hampstead, N.W.
1880. ‡Minchin, G. M., M.A., F.R.S., Professor of Mathematics in the Royal Indian Engineering College, Cooper's Hill, Surrey.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1901. *Mitchell, Andrew Acworth. 7 Huntly-gardens, Glasgow.
1883. ‡Mitchell, Charles T., M.A. 41 Addison-gardens North, Kensington, W.
1883. ‡Mitchell, Mrs. Charles T. 41 Addison-gardens North, Kensington, W.
1901. *Mitchell, G. A. 5 West Regent-street, Glasgow.
1885. ‡Mitchell, P. Chalmers, M.A., Sec.Z.S. 3 Hanover-square, W.
1895. *Moat, William, M.A. Johnson Hall, Eccleshall, Staffordshire.
1885. ‡Moffat, William. 7 Queen's-gardens, Aberdeen.
1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1877. *Molloy, Right Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1884. ‡Monaghan, Patrick. Halifax (Box 317), Nova Scotia, Canada.
1900. §Moncrton, H. W., F.L.S., F.G.S. 3 Harcourt-buildings, Temple, E.C.
1887. *Mond, Ludwig, Ph.D., F.R.S., F.C.S. (Pres. B, 1896). 20 Avenue-road, Regent's Park, N.W.
1891. *Mond, Robert Ludwig, M.A., F.R.S.E., F.G.S. 20 Avenue-road, Regent's Park, N.W.
1882. *Montagu, Sir Samuel, Bart., M.P. 12 Kensington Palace-gardens, W.
1892. ‡Montgomery, Very Rev. J. F. 17 Athole-crescent, Edinburgh.

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Year of Election.

1872. ‡Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1896. ‡Moore, A. W., M.A. Woodbourne House, Douglas, Isle of Man.
1894. §Moore, Harold E. Oaklands, The Avenue, Beckenham, Kent.
1890. ‡Moore, Major, R.E. School of Military Engineering, Chatham.
1901. *Moore, Robert T. 142 St. Vincent-street, Glasgow.
1896. *Mordey, W. M. 82 Victoria-street, S.W.
1891. ‡Morel, P. Lavernock House, near Cardiff.
1901. *Moreno, Francisco P. Argentine Legation, 16 Kensington Palace-gardens, W.
1881. ‡Morgan, Alfred. 50 West Bay-street, Jacksonville, Florida, U.S.A.
1895. ‡Morgan, C. Lloyd, F.R.S., F.G.S., Principal of University College, Bristol. 16 Canynge-road, Clifton, Bristol.
1873. ‡Morgan, Edward Delmar, F.R.G.S. 15 Roland-gardens, South Kensington, S.W.
1891. ‡Morgan, F. Forest Lodge, Ruspidge, Gloucestershire.
1896. §Morgan, George. 21 Upper Parliament-street, Liverpool.
1902. ‡Morgan, Gilbert T., D.Sc., F.I.C. Royal College of Science, S.W.
1887. ‡Morgan, John Gray. 38 Lloyd-street, Manchester.
1902. *Morgan, Septimus Vaughan. 37 Harrington-gardens, S.W.
1882. ‡Morgan, Thomas, J.P. Cross House, Southampton.
1901. *Morison, James. Perth.
1892. ‡Morison, John, M.D., F.G.S. Victoria-street, St. Albans.
1889. §Morison, J. Rutherford, M.D. 14 Saville-row, Newcastle-upon-Tyne.
1893. ‡Morland, John, J.P. Glastonbury.
1891. ‡Morley, H. The Gas Works, Cardiff.
1883. *Morley, Henry Forster, M.A., D.Sc., F.C.S. 5 Lyndhurst-road, Hampstead, N.W.
1889. ‡Morley, The Right Hon. John, M.A., LL.D., M.P., F.R.S. Flowermead, Wimbledon Park, Surrey.
1896. ‡Morrell, R. S. Caius College, Cambridge.
1881. ‡Morrell, W. W. York City and County Bank, York.
1883. ‡Morris, C. S. Millbrook Iron Works, Landore, South Wales.
1892. ‡Morris, Daniel, C.M.G., M.A., D.Sc., F.L.S. Barbados, West Indies.
1899. ‡Morris, G. Harris, B.Sc., Ph.D., F.I.C. Helenalea, South Hill Park, Bromley, Kent.
1883. ‡Morris, George Lockwood. Millbrook Iron Works, Swansea.
1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.
1896. *Morris, J. T. 13 Somers-place, W.
1888. ‡Morris, J. W. 27 Green Park, Bath.
1874. §Morrison, G. James, M.Inst.C.E. 7 The Sanctuary, Westminster, S.W.
1899. §Morrow, Captain John, M.Sc. 7 Rockleaze-avenue, Sneyd Park, Bristol.
1865. ‡Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1858. *Morton, Henry Joseph. 2 Westbourne-villas, Scarborough.
1887. ‡Morton, Percy, M.A. Illtyd House, Brecon, South Wales.
1886. *Morton, P. F. 15 Ashley-place, Westminster, S.W.
1896. *Morton, William B., M.A., Professor of Natural Philosophy in Queen's College, Belfast.
1878. *Moss, John Francis, F.R.G.S. (Local Sec. 1879). Beechwood, Brincliffe, Sheffield.
1876. §Moss, Richard Jackson, F.I.C., M.R.I.A. Royal Dublin Society, and St. Aubyn's, Ballybrack, Co. Dublin.

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Year of Election.

1864. *Mosse, J. R. 5 Clanricarde-gardens, Tunbridge Wells.
1892. ‡Mossman, R. C., F.R.S.E. 10 Blacket-place, Edinburgh.
1873. ‡Mossman, William. St. Hilda's, Frizinghall, Bradford.
1892. *Mostyn, S. G., M.A., M.B. City Hospital for Infectious Diseases, Walker Gate, Newcastle-upon-Tyne.
1866. ‡Mott, Frederick T., F.R.G.S. Crescent House, Leicester.
1878. *Moulton, J. Fletcher, M.A., K.C., M.P., F.R.S. 57 Onslow-square, S.W.
1863. ‡Mounsey, Edward. Sunderland.
1877. ‡Mount-Edgcumbe, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.
1899. §Mowll, Martyn. Chaldercot, Leyburne-road, Dover.
1887. ‡Moxon, Thomas B. County Bank, Manchester.
1888. ‡Moyle, R. E., M.A., F.C.S. Heightley, Chudleigh, Devon.
1884. ‡Moyse, C. E., B.A., Professor of English Language and Literature in McGill College, Montreal. 802 Sherbrooke-street, Montreal, Canada.
1884. ‡Moyse, Charles E. 802 Sherbrooke-street, Montreal, Canada.
1899. *Muff, Herbert B. Geological Survey Office, Edinburgh.
1894. ‡*Mugliston, Rev. J., M.A. Newick House, Cheltenham.*
1902. §Muir, Arthur H., C.A. 2 Wellington-place, Belfast.
1874. ‡Muir, M. M. Pattison, M.A. Gonville and Caius College, Cambridge.
1872. *Muirhead, Alexander, D.Sc., F.C.S. 12 Carteret-street, Queen Anne's-gate, Westminster, S.W.
1876. *Muirhead, Robert Franklin, M.A., B.Sc. 24 Kersland-street, Hillhead, Glasgow.
1902. §Mullan, James. Castlerock, Co. Derry.
1884. *Müller, Hugo, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, N.W.
1880. ‡Muller, Hugo M. 1 Grünanger-gasse, Vienna.
1897. ‡Mullins, W. E. Hampstead, N.W.
1898. ‡Mumford, C. E. Bury St. Edmunds.
1901. *Munby, Alan E. 7 Chalcot-crescent, Primrose Hill, N.W.
Munby, Arthur Joseph. 6 Fig Tree-court, Temple, E.C.
1876. ‡Munro, Donald, M.D., F.C.S. The University, Glasgow.
1901. ‡Munro, Donald, M.D., J.P. Wheatholm, Pollokshaws, Glasgow.
1898. ‡Munro, John, Professor of Mechanical Engineering in the Merchant Venturers' Technical College, Bristol.
1883. *Munro, Robert, M.A., M.D. (Pres. H, 1893). 48 Manor-place, Edinburgh.
1855. ‡Murdoch, James Barclay. Capelrig, Mearns, Renfrewshire.
1890. ‡Murphy, A. J. Preston House, Leeds.
1889. ‡Murphy, James, M.A., M.D. Holly House, Sunderland.
1884. §Murphy, Patrick. Marcus-square, Newry, Ireland.
1887. ‡Murray, A. Hazeldean, Kersal, Manchester.
1891. ‡Murray, G. R. M., F.R.S., F.R.S.E., F.L.S. British Museum (Natural History), South Kensington, S.W.
1859. ‡Murray, John, M.D. Forres, Scotland.
1884. ‡Murray, Sir John, K.C.B., LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. E, 1899). Challenger Lodge, Wardie, Edinburgh.
1884. ‡Murray, J. Clark, LL.D. 111 McKay-street, Montreal, Canada.
1903. §Murray, J. D., Rowbottom-square, Wigan.
1872. ‡Murray, J. Jardine, F.R.C.S.E. 99 Montpellier-road, Brighton.
1892. ‡Murray, T. S. 1 Nelson-street, Dundee.
1863. ‡Murray, William, M.D. 9 Ellison-place, Newcastle-on-Tyne.
1874. §Musgrave, Sir James, Bart., D.L. Drumglass House, Belfast.
1897. ‡Musgrave, James, M.D. 511 Bloor-street West, Toronto, Canada

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Year of Election.

1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1891. ‡Muybridge, Eadweard. University of Pennsylvania, Philadelphia, U.S.A.
1902. ‡Myddleton, Alfred. 62 Duncairn-street, Belfast.
1902. *Myers, Charles S., M.A., M.D. 62 Holland-park, W.
1890. *Myres, John L., M.A., F.S.A. 1 Norham-gardens, Oxford.

1886. ‡Nagel, D. H., M.A. (Local Sec. 1894). Trinity College, Oxford.
1892. *Nairn, Michael B. Kirkcaldy, N.B.
1890. §Nalder, Francis Henry. 34 Queen-street, E.C.
1876. ‡Napier, James S. 9 Woodside-place, Glasgow.
1872. ‡Nares, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. 11 Claremont-road, Surbiton.
1887. ‡Nason, Professor Henry B., Ph.D. Troy, New York, U.S.A.
1896. ‡Neal, James E., U.S. Consul. 26 Chapel-street, Liverpool.
1887. §Neild, Charles. 19 Chapel-walks, Manchester.
1883. *Neild, Theodore, B.A. The Vista, Leominster.
1887. ‡*Neill, Robert, jun. Beech Mount, Higher Broughton, Manchester.*
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1897. ‡Nesbitt, Beattie S. A., M.D. 71 Grosvenor-street, Toronto, Canada.
1898. §Nevill, Rev. J. H. N., M.A. The Vicarage, Stoke Gabriel, South Devon.
1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1889. ‡Neville, F. H., M.A., F.R.S. Sidney College, Cambridge.
1869. ‡*Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.*
1889. *Newall, H. Frank, M.A., F.R.S., F.R.A.S. Madingley Rise, Cambridge.
1901. §Newbigin, Miss Marion, D.Sc. 1 Greenbank-road, Morningside, Edinburgh.
1886. ‡Newbolt, F. G. Oakley Lodge, Weybridge, Surrey.
1901. ‡Newman, F. H. Tullie House, Carlisle.
1889. §Newstead, A. H. L., B.A. 38 Green-street, Bethnal Green, N.E.
1860. *Newton, Alfred, M.A., F.R.S., F.L.S. (Pres. D, 1887; Council 1875–82), Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalene College, Cambridge.
1892. ‡Newton, E. T., F.R.S., F.G.S. Geological Museum, Jermyn-street, S.W.
1867. ‡Nicholl, Thomas. Dundee.
1887. *Nicholson, John Carr, J.P. Moorfield House, Headingley, Leeds.
1884. ‡Nicholson, Joseph S., M.A., D.Sc. (Pres. F, 1893), Professor of Political Economy in the University of Edinburgh. Eden Lodge, Newbattle-terrace, Edinburgh.
1883. ‡Nicholson, Richard, J.P. Whinfield, Hesketh Park, Southport.
1887. ‡Nicholson, Robert H. Bourchier. 21 Albion-street, Hull.
1893. ‡Nickolls, John B., F.C.S. The Laboratory, Guernsey.
1887. ‡Nickson, William. Shelton, Sibson-road, Sale, Manchester.
1901. ‡Nicol, James, City Chamberlain. Glasgow.
1885. ‡Nicol, W. W. J., D.Sc., F.R.S.E. 15 Blacket-place, Edinburgh.
1896. ‡Nisbet, J. Tawse. 175 Lodge-lane, Liverpool.
1878. ‡Niven, Charles, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Aberdeen. 6 Chanonry, Old Aberdeen.
1877. ‡Niven, Professor James, M.A. King's College, Aberdeen.

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Year of Election.

1863. *Noble, Sir Andrew, Bart., K.C.B., F.R.S., F.R.A.S. F.C.S. (Pres. G, 1890; Council, 1903; Local Sec. 1863). Elswick Works, and Jesmond Dene House, Newcastle-upon-Tyne.
1879. †Noble, T. S. Lendal, York.
1887. †Nodal, John H. The Grange, Heaton Moor, near Stockport.
1863. §Norman, Rev. Canon Alfred Merle, M.A., D.C.L., LL.D., F.R.S., F.L.S. The Red House, Berkhamsted.
1888. †Norman, George. 12 Brock-street, Bath.
1865. †Norris, Richard, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. †Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales
1883. *Norris, William G. Dale House, Coalbrookdale, R.S.O., Shropshire.
Norton, The Right Hon. Lord, K.C.M.G. 35 Eaton-place, S.W.; and Hamshall, Birmingham.
1886. †Norton, Lady. 35 Eaton-place, S.W.; and Hamshall, Birmingham.
1894. §Notcutt, S. A., LL.M., B.A., B.Sc. (Local Sec. 1895). Constitution Hill, Ipswich.
1903. §Noton, John. 45 Part-street, Southport.
Nowell, John. Farnley Wood, near Huddersfield.
1896. †Nugent, the Right Rev. Monsignor. Harewood House, Formby, Lancashire.

1898. *O'Brien, Neville Forth. Queen Anne's-mansions, S.W.
1878. †O'Conor Don, The. Clonalis, Castlerea, Ireland.
1883. †Odgers, William Blake, M.A., LL.D. 4 Elm-court, Temple, E.C.
1858. *Odling, William, M.B., F.R.S., V.P.C.S. (Pres. B, 1864; Council 1865–70), Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.
1884. †Odlum, Edward, M.A. Pembroke, Ontario, Canada.
1857. †O'Donnavan, William John. 54 Kenilworth-square, Rathgar, Dublin.
1894. §Ogden, James. Kilner Deyne, Rochdale.
1902. §Ogden, James Neal. Claremont, Heaton Chapel, Stockport.
1896. †*Ogden, Thomas.* 4 *Prince's-avenue, Liverpool.*
1885. †Ogilvie, Alexander, LL.D. Gordon's College, Aberdeen.
1876. †Ogilvie, Campbell P. Sizewell House, Leiston, Suffolk.
1885. †Ogilvie, F. Grant, M.A., B.Sc., F.R.S.E. (Local Sec. 1892). Board of Education, S.W.
1859. †Ogilvy, Rev. C. W. Norman. Baldan House, Dundee.
*Ogle, William, M.D., M.A. The Elms, Duffield-road, Derby.
1884. †O'Halloran, J. S., C.M.G. Royal Colonial Institute, Northumberland-avenue, W.C.
1881. †Oldfield, Joseph. Lendal, York.
1896. †Oldham, G. S. Town Hall, Birkenhead.
1892. †Oldham, H. Yule, M.A., F.R.G.S., Lecturer in Geography in the University of Cambridge. King's College, Cambridge.
1853. †Oldham, James, M.Inst.C.E. Cottingham, near Hull.
1885. †Oldham, John. River Plate Telegraph Company, Monte Video.
1893. *Oldham, R. D., F.G.S., Geological Survey of India. Care of Messrs. H. S. King & Co., Cornhill, E.C.
1863. †Oliver, Daniel, LL.D., F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. 10 Kew Gardens-road, Kew Surrey.
1887. †Oliver, F. W., D.Sc., F.L.S., Professor of Botany in University College, London. 2 The Vale, Chelsea, S.W.
1883. §Oliver, Samuel A. Bellingham House, Wigan, Lancashire.
1889. §Oliver, Professor T., M.D. 7 Ellison-place, Newcastle-upon-Tyne.
1882. §Olsen, O. T., F.L.S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.

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Year of Election.

1860. *Ommanney, Admiral Sir Erasmus, K.C.B., LL.D., F.R.S., F.R.A.S., F.R.G.S. (Pres. E, 1877; Council 1873–80, 1884–90). 29 Connaught-square, Hyde Park, W.
1880. *Ommanney, Rev. E. A. St. Michael's and All Angels, Portsea, Hants.
1902. †O'Neill, Henry, M.D. 6 College-square East, Belfast.
1902. §O'Neill, James, M.A. 5 College-square East, Belfast.
1872. ‡*Onslow, D. Robert. New University Club, St. James's, S.W.*
1883. †Oppert, Gustav, Professor of Sanskrit in the University of Berlin.
1902. †O'Reilly, Patrick Joseph. 7 North Earl-street, Dublin.
1899. †Orling, Axel. Moorgate Station-chambers, E.C.
1858. †Ormerod, T. T. Brighouse, near Halifax.
1883. †Orpen, Miss. St. Leonard's, Kilkenny, Co. Dublin.
1884. *Orpen, Lieut.-Colonel R. T., R.E. Monksgrange, Enniscorthy, Co. Wexford.
1884. *Orpen, Rev. T. H., M.A. Binnbrooke, Cambridge.
1901. §Orr, Alexander Stewart. Care of Messrs. Maraland, Price & Co., Mazagon, Bombay, India.
1899. †Osborn, Dr. F. A. The Châlet, Dover.
1897. †Osborne, James K. 40 St. Joseph-street, Toronto, Canada.
1901. †Osborne, W. A., D.Sc. University College, W.C.
1887. §O'Shea, L. T., B.Sc. University College, Sheffield.
1897. †Osler, E. B., M.P. Rosedale, Toronto, Canada.
1865. *Osler, Henry F. Coppy Hill, Linthurst, near Bromsgrove, Birmingham.
1884. †Osler, Professor William, M.D., LL.D., F.R.S. Johns Hopkins University, Baltimore, U.S.A.
1884. ‡*O'Sullivan, James, F.C.S. 71 Spring Terrace-road, Burton-on-Trent.*
1882. *Oswald, T. R. Castle Hall, Milford Haven.
1881. *Ottewell, Alfred D. 14 Mill Hill-road, Derby.
1896. †Oulton, W. Hillside, Gateacre, Liverpool.
1882. †Owen, Rev. C. M., M.A. St. George's, Edgbaston, Birmingham.
1903. *Owen, Edwin. Terra Nova, Birkdale, Lancashire.
1889. *Owen, Alderman H. C. Compton, Wolverhampton.
1896. §Owen, Peter. The Elms, Capenhurst, Chester.

1903. *Page, Miss Ellen Ina. Turret House, Felpham, Sussex.
1889. †Page, Dr. F. 1 Saville-place, Newcastle-upon-Tyne.
1883. †Page, George W. Fakenham, Norfolk.
1883. †Page, Joseph Edward. 12 Saunders-street, Southport.
1894. †Paget, Octavius. 158 Fenchurch-street, E.C.
1898. †Paget, The Right Hon. Sir R. H., Bart. Cranmore Hall, Shepton Mallet.
1884. †Paine, Cyrus F. Rochester, New York, U.S.A.
1875. †Paine, William Henry, M.D. Stroud, Gloucestershire.
1870. *Palgrave, Robert Harry Inglis, F.R.S., F.S.S. (Pres. F, 1883). Belton, Great Yarmouth.
1896. †Pallis, Alexander. Tatoi, Aigburth-drive, Liverpool.
1889. †Palmer, Sir Charles Mark, Bart., M.P. Grinkle Park, Yorkshire.
1878. *Palmer, Joseph Edward. Rose Lawn, Ballybrack, Co. Dublin.
1866. §Palmer, William. Waverley House, Waverley-street, Nottingham.
1886. †Panton, George A., F.R.S.E. 73 Westfield-road, Edgbaston, Birmingham.
1883. †Park, Henry. Wigan.
1883. †Park, Mrs. Wigan.

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Year of Election.

1880. *Parke, George Henry, F.L.S., F.G.S. St. John's, Wakefield, Yorkshire.
1904. §PARKER, E. H., M.A. (LOCAL TREASURER 1904.) Thorneycreek, Herschel-road, Cambridge.
1898. ‡Parker, G., M.D. 14 Pembroke-road, Clifton, Bristol.
1903. §Parker, Rev. J. Dunne, LL.D., D.C.L., F.R.A.S. Bennington House, viâ Stevenage, Hertfordshire.
1886. ‡Parker, Lawley. Chad Lodge, Edgbaston, Birmingham.
1899. ‡*Parker, Mark.* 30 *Upper Fant-road, Maidstone.*
1891. ‡PARKER, WILLIAM NEWTON, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff.
1899. *Parkin, John. Blaithwaite, Carlisle.
1879. *Parkin, William. The Mount, Sheffield.
1887. ‡Parkinson, James. Greystones, Langho, Blackburn.
1859. ‡Parkinson, Robert, Ph.D. Yewbarrow House, Grange-over-Sands.
1903. §Parry, Joseph, M.Inst.C.E. Woodbury, Waterloo-road, Liverpool.
1883. ‡Parson, T. Cooke, M.R.C.S. Atherston House, Clifton, Bristol.
1878. ‡PARSONS, Hon. C. A., M.A., F.R.S., M.Inst.C.E. Holeyn Hall, Wylam-on-Tyne.
1898. *Partridge, Miss Josephine M. 15 Grosvenor-crescent, S.W.
1898. ‡Pass, Alfred C. Clifton Down, Bristol.
1887. ‡PATERSON, A. M., M.D., Professor of Anatomy in University College, Liverpool.
1897. ‡Paterson, John A. 23 Walmer-road, Toronto, Canada.
1896. ‡Paton, A. A. Greenbank-drive, Wavertree, Liverpool.
1897. ‡PATON, D. NOËL, M.D. 33 George-square, Edinburgh.
1883. *Paton, Rev. Henry, M.A. 120 Polwarth-terrace, Edinburgh.
1884. *Paton, Hugh. Box 2400, Montreal, Canada.
1902. §Patterson, Robert, F.Z.S., M.R.I.A. Ivy Dene, Malone Park, Belfast.
1876. ‡Patterson, T. L. Maybank, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡PATTINSON, JOHN, F.C.S. 75 The Side, Newcastle-upon-Tyne.
1879. *Patzer, F. R. Clayton Lodge, Newcastle, Staffordshire.
1883. ‡Paul, George. 10 St. Mary's-avenue, Harrogate.
1892. ‡Paul, J. Balfour. 30 Heriot-row, Edinburgh.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S. 35 Grosvenor-street, W.
1887. *Paxman, James. Stisted Hall, near Braintree, Essex.
1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.
1881. ‡Payne, J. Buxton. 15 Mosley-street, Newcastle-upon-Tyne.
1877. *Payne, J. C. Charles, J.P. Albion-place, The Plains, Belfast.
1881. ‡Payne, Mrs. Albion-place, The Plains, Belfast.
1866. ‡Payne, Joseph F., M.D. 78 Wimpole-street, W.
1888. *Paynter, J. B. Hendford Manor House, Yeovil.
1886. ‡Payton, Henry. Wellington-road, Birmingham.
1876. ‡Peace, G. H. Monton Grange, Eccles, near Manchester.
1879. ‡Peace, William K. Moor Lodge, Sheffield.
1885. ‡PEACH, B. N., F.R.S., F.R.S.E., F.G.S. Geological Survey Office, Edinburgh.
1875. ‡Peacock, Thomas Francis. 12 South-square, Gray's Inn, W.C.
1886. *Pearce, Mrs. Horace. Orsett House, Birmingham-road, Kidderminster.
1886. ‡*Pearsall, Howard D.* 10 *Willow-road, Hampstead, N.W.*
1883. ‡Pearson, Arthur A. Colonial Office, S.W.
1891. ‡Pearson, B. Dowlais Hotel, Cardiff.
1893. *Pearson, Charles E. Hillcrest, Lowdham, Nottinghamshire.
1898. §Pearson, George. Bank-chambers, Baldwin-street, Bristol.
1883. ‡Pearson, Miss Helen E. Oakhurst, Birkdale, Southport.
1881. ‡Pearson, John. Glentworth House, The Mount, York.

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Year of Election.

1883. ‡Pearson, Mrs. Glentworth House, The Mount, York.
1892. ‡Pearson, J. M. John Dickie-street, Kilmarnock.
1881. ‡Pearson, Richard. 57 Bootham, York.
1889. ‡Pease, Howard. Enfield Lodge, Benwell, Newcastle-upon-Tyne.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, LL.D., F.S.A., F.L.S., F.R.G.S. (Vice-President, 1904.) Bank House, Wisbech, Cambridgeshire.
1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
1885. ‡*Peddie, William, D.Sc., F.R.S.E. 2 Cameron-park, Edinburgh.*
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1878. *Peek, William. 20 Brier-road, Fulham, S.W.
1901. *Peel, Hon. William, M.P. 13 King's Bench-walk, Temple, E.C.
1881. ‡Pegge, J. Wallace. 21 Queen Anne's-gate, S.W.
1878. ‡Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, W.C.
1887. §Pendlebury, William H., M.A., F.C.S. (Local Sec. 1899). Woodford House, Mountfields, Shrewsbury.
1894. §Pengelly, Miss. Lamorna, Torquay.
1897. ‡Penhallow, Professor D. P., M.A. McGill University, Montreal, Canada.
1896. ‡Pennant, P. P. Nantlys, St. Asaph.
1898. ‡Pentecost, Harold, B.A. Clifton College, Bristol.
1889. ‡Percival, Archibald Stanley, M.A., M.B. 16 Ellison-place, Newcastle-upon-Tyne.
1898. ‡Percival, Francis W., M.A., F.R.G.S. 2 Southwick-place, W.
1895. ‡Percival, John, M.A., Professor of Botany in the South-Eastern Agricultural College, Wye, Kent.
*Perigal, Frederick. Chalcots, Lower Kingswood, Reigate.
1894. ‡Perkin, A. G., F.R.S., F.R.S.E., F.C.S., F.I.C. 8 Montpelier-terrace, Hyde Park, Leeds.
1902. §Perkin, F. Mollwo, Ph.D. 5 Fyson-road, Forest Hill, S.E.
1868. *Perkin, William Henry, Ph.D., LL.D., F.R.S., F.C.S. (Pres. B, 1876; Council 1880–86). The Chestnuts, Sudbury, Harrow, Middlesex.
1884. ‡Perkin, William Henry, jun., LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. B, 1900; Council 1901–), Professor of Organic Chemistry in the Owens College, Manchester. Fairview, Wilbraham-road, Fallowfield, Manchester.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1898. *Perman, E. P., D.Sc. University College, Cardiff.
1885. ‡Perrin, Miss Emily. 31 St John's Wood Park, N.W.
1886. ‡Perrin, Henry S. 31 St. John's Wood Park, N.W.
1886. ‡Perrin, Mrs. 31 St. John's Wood Park, N.W.
1874. *Perry, John, M.E., D.Sc., F.R.S. (Pres. G, 1902; Council 1901–), Professor of Mechanics and Mathematics in the Royal College of Science, S.W.
1883. ‡Perry, Russell R. 34 Duke-street, Brighton.
1900. §Petavel, J. E. The Owens College, Manchester.
1897. ‡Peters, Dr. George A. 171 College-street, Toronto, Canada.
1898. ‡Pethick, William. Woodside, Stoke Bishop, Bristol.
1901. ‡Pethybridge, G. H. Museum of Science and Art, Dublin.
1883. ‡Petrie, Miss Isabella. Stone Hill, Rochdale.
1895. ‡Petrie, W. M. Flinders, D.C.L., F.R.S. (Pres. H, 1895), Professor of Egyptology in University College, W.C.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 13 Fourth-avenue, Hove, Brighton.
1886. ‡Phelps, Major-General A. 23 Augustus-road, Edgbaston, Birmingham.

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Year of Election.

1863. *Phené, John Samuel, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton terrace, Oakley-street, S.W.
1896. †Philip, George, jun. Weldon, Bidston, Cheshire.
1903. §Philip, James C. 20 Westfield-terrace, Aberdeen.
1892. †Philip, R. W., M.D. 4 Melville-crescent, Edinburgh.
1870. †Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. The Oak House, Macclesfield.
1877. §Philips, T. Wishart. Elizabeth Lodge, George-lane, Woodford, Essex.
1863. †Philipson, Sir G. H. 7 Eldon-square, Newcastle-upon-Tyne.
1883. †Phillips, Arthur G. 20 Canning-street, Liverpool.
1899. †Phillips, Charles E. S. Castle House, Shooter's Hill, Kent.
1894. †Phillips, Staff-Commander E. C. D., R.N., F.R.G.S. 14 Hargreaves-buildings, Chapel-street, Liverpool.
1887. †*Phillips, H. Harcourt, F.C.S.* 183 *Moss-lane East, Manchester.*
1902. †Phillips, J. St. J., B.E. 64 Royal-avenue, Belfast.
1890. †Phillips, R. W., M.A., D.Sc., Professor of Biology in University College, Bangor.
1883. †Phillips, S. Rees. Wonford House, Exeter.
1881. †Phillips, William. 9 Bootham-terrace, York.
1898. †Philps, Captain Lambe. 7 Royal-terrace, Weston-super-Mare.
1884. *Pickard, Rev. H. Adair, M.A. Airedale, Oxford.
1883. *Pickard, Joseph William. Oatlands, Lancaster.
1901. §Pickard, Robert H., D.Sc. Isca, Merlin-road, Blackburn.
1894. †Pickard-Cambridge, Rev. O., M.A., F.R.S. Bloxworth Rectory, Wareham.
1885. *Pickering, Spencer P. U., M.A., F.R.S. Harpenden, Herts.
1884. *Pickett, Thomas E., M.D. Maysville, Mason Co., Kentucky, U.S.A.
1888. *Pidgeon, W. R. 42 Porchester-square, W.
1884. †Pike, L. G., M.A., F.Z.S. 12 King's Bench-walk, Temple, E.C.
1865. †Pike, L. Owen. 4a Marlborough-gate, Hyde Park, W.
1873. †Pike, W. H., M.A., Ph.D. Toronto, Canada.
1896. *Pilkington, A. C. Rocklands, Rainhill, Lancashire.
1896. *Pilling, William. Rosario, Heene-road, West Worthing.
1877. †Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
1868. †*Pinder, T. R. St. Andrew's, Norwich.*
1876. †Pirie, Rev. G., M.A. (Local Sec. 1885), Professor of Mathematics in the University of Aberdeen. 33 College Bounds, Old Aberdeen.
1887. †Pitkin, James. 56 Red Lion-street, Clerkenwell, E.C.
1875. †Pitman, John. Redcliff Hill, Bristol.
1883. †*Pitt, George Newton, M.A., M.D.* 24 *St. Thomas-street, Borough, S.E.*
1883. †Pitt, Sydney. 16 St. Andrew's-street, Holborn-circus, E.C.
1893. *Pitt, Walter, M.Inst.C.E. South Stoke House, near Bath.
1900. *Platts, Walter. Fairmount, Bingley.
1898. †Playne, H. C. 28 College-road, Clifton, Bristol.
1893. †Plowright, Henry J. Brampton Foundries, Chesterfield.
1897. †Plummer, J. H. Bank of Commerce, Toronto, Canada.
1898. §Plummer, W. E., M.A., F.R.A.S. The Observatory, Bidston, Birkenhead.
1899. †Plumptre, Fitzwalter. Goodnestone, Dover.
1857. †Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Queen's Co., Ireland.
1900. *Pocklington, H. Cabourn. 41 Virginia-road, Leeds.
1881. §Pocklington, Henry. 20 Park-row, Leeds.
1888. †*Pocock, Rev. Francis.* 4 *Brunswick-place, Bath.*

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Year of Election.

1896. ‡Pollard, James. High Down, Hitchin, Herts.
1898. ‡*Pollen, Rev. G. C. H., F.G.S. Stonyhurst College, Blackburn.*
1896. *Pollex, Albert. Tenby House, Egerton Park, Rockferry.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1891. ‡Pomeroy, Captain Ralph. 201 Newport-road, Cardiff.
1900. §Pope, W. J., F.R.S., Professor of Chemistry in the Municipal School of Technology, Manchester. 16 Hope-street, Higher Broughton, Manchester.
1892. ‡Popplewell, W. C., M.Sc., Assoc.M.Inst.C.E. The Yew, Marple, near Stockport.
1868. ‡Portal, Sir Wyndham S., Bart. Malshanger, Basingstoke.
1901. §Porter, Alfred W., B.Sc. 87 Parliament Hill-mansions, Lissenden-gardens, N.W.
1883. *Porter, Rev. C. T., LL.D., D.D. All Saints' Vicarage, Southport.
1883. ‡Postgate, Professor J. P., M.A. University College, Gower-street, W.C.
1887. ‡*Potter, Edmund P. Hollinhurst, Bolton.*
1883. ‡Potter, M. C., M.A., F.L.S., Professor of Botany in the College of Science, Newcastle-upon-Tyne. 14 Highbury, Newcastle-upon-Tyne.
1886. *Poulton, Edward B., M.A., F.R.S., F.L.S., F.G.S., F.Z.S. (Pres. D, 1896; Council 1895–1901), Professor of Zoology in the University of Oxford. Wykeham House, Banbury-road, Oxford.
1898. *Poulton, Edward Palmer. Wykeham House, Banbury-road, Oxford.
1873. *Powell, Sir Francis S., Bart., M.P., F.R.G.S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, W.
1887. *Powell, Horatio Gibbs, F.R.G.S. Wood Villa, Tettenhall Wood, Wolverhampton.
1883. ‡Powell, John. Brynmill-crescent, Swansea.
1894. *Powell, Sir Richard Douglas, Bart., M.D. 62 Wimpole-street, Cavendish-square, W.
1875. ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.
1887. §Pownall, George H. 20 Birchin-lane, E.C.
1867. ‡Powrie, James. Reswallie, Forfar.
1883. ‡Poynting, J. H., D.Sc., F.R.S. (Pres. A, 1899), Professor of Physics in the University, Birmingham. 10 Ampton-road, Edgbaston, Birmingham.
1884. *Prankerd, A. A., D.C.L. 66 Banbury-road, Oxford.
1869. *Preece, Sir William Henry, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1888; Council 1888–95, 1896–1902). Gothic Lodge, Wimbledon Common, Surrey; and 8 Queen Anne's-gate, S.W.
1888. *Preece, W. Llewellyn. Bryn Helen, Woodborough-road, Putney, S.W.
1892. §Prentice, Thomas. Willow Park, Greenock.
1889. §Preston, Alfred Eley, M.Inst.C.E., F.G.S. 14 The Exchange, Bradford, Yorkshire.
1894. ‡Preston, Arthur E. Piccadilly, Abingdon, Berkshire.
1893. *Preston, Martin Inett. 48 Ropewalk, Nottingham.
1884. *Prevost, Major L. de T., 2nd Battalion Argyll and Sutherland Highlanders.
1903. §Price, Edward E. Oaklands, Oaklands-road, Bromley, Kent.
Price, J. T. Neath Abbey, Glamorganshire.
1888. ‡Price, L. L. F. R., M.A., F.S.S. (Pres. F, 1895; Council, 1893–). Oriel College, Oxford.
1875. *Price, Rees. 163 Bath-street, Glasgow.

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Year of Election.

1891. ‡Price, William. 40 Park-place, Cardiff.
1897. *Price, W. A., M.A. The Mill House, Broomfield, Chelmsford.
1897. ‡Primrose, Dr. Alexander. 196 Simcoe-street, Toronto, Canada.
1892. ‡Prince, Professor Edward E., B.A. Ottawa, Canada.
1889. *Pritchard, Eric Law, M.D., M.R.C.S. 70 Fairhazel-gardens, South Hampstead, N.W.
1876. *Pritchard, Urban, M.D., F.R.C.S. 26 Wimpole-street, W.
1888. ‡Probyn, Leslie C. 79 Onslow-square, S.W.
1881. §Procter, John William. Ashcroft, York.
1863. ‡Proctor, R. S. Grey-street, Newcastle-upon-Tyne.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1884. *Proudfoot, Alexander, M.D. 100 State-street, Chicago, U.S.A.
1879. *Prouse, Oswald Milton, F.G.S. Alvington, Ilfracombe.
1872. *Pryor, M. Robert. Weston Park, Stevenage, Herts.
1871. *Puckle, Rev. T. J. Chestnut House, Huntingdon-road, Cambridge.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. *Pullar, Sir Robert, F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Brahan, Perth.
1891. ‡Pullen, W. W. F. University College, Cardiff.
1887. §Pumphrey, William (Local Sec. 1888). 2 Oakland-road, Redland, Bristol.
1885. ‡Purdie, Thomas, B.Sc., Ph.D., F.R.S., Professor of Chemistry in the University of St. Andrews. 14 South-street, St. Andrews, N.B.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1874. ‡Purser, Frederick, M.A. Rathmines Castle, Dublin.
1866. ‡Purser, Professor John, M.A., LL.D., M.R.I.A. (Pres. A, 1902). Rathmines Castle, Dublin.
1878. ‡Purser, John Mallet. 3 Wilton-terrace, Dublin.
1884. *Purves, W. Laidlaw. 20 Stratford-place, Oxford-street, W.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1898. *Pye, Miss E. St. Mary's Hall, Rochester.
1883. §Pye-Smith, Arnold. Willesley, Park Hill Rise, Croydon.
1883. ‡Pye-Smith, Mrs. Willesley, Park Hill Rise, Croydon.
1868. ‡Pye-Smith, P. H., M.D., F.R.S. 48 Brook-street, W.; and Guy's Hospital, S.E.
1879. ‡Pye-Smith, R. J. 350 Glossop-road, Sheffield.

1893. ‡Quick, James. University College, Bristol.
1894. ‡Quick, Professor W. J. University of Missouri, Columbia, U.S.A.

1870. ‡Rabbits, W. T. 6 Cadogan-gardens, S.W.
1870. ‡*Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.*
1896. §Radcliffe, Herbert. Balderstone Hall, Rochdale.
1855. *Radstock, The Right Hon. Lord. Mayfield, Woolston, Southampton.
1887. *Ragdale, John Rowland. The Beeches, Stand, near Manchester.
1864. ‡*Rainey, James T.* 3 *Kent-gardens, Ealing, W.*
1898. *Raisin, Miss Catherine A., D.Sc. Bedford College, York-place, Baker-street, W.
1896. *Ramage, Hugh. St. John's College, Cambridge.
1894. *Rambaut, Arthur A., M.A., D.Sc., F.R.S., F.R.A.S., M.R.I.A. Radcliffe Observatory, Oxford.
1863. ‡Ramsay, Alexander. 3 Cowper-road, Acton, Middlesex, W.
1884. ‡Ramsay, George G., LL.D., Professor of Humanity in the University of Glasgow. 6 The College, Glasgow.

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Year of Election.

1884. ‡Ramsay, Mrs. G. G. 6 The College, Glasgow.
1861. ‡Ramsay, John. Kildalton, Argyllshire.
1885. ‡Ramsay, Major. Straloch, N.B.
1889. ‡Ramsay, Major R. G. W. Bonnyrigg, Edinburgh.
1876. *Ramsay, Sir William, K.C.B., Ph.D., F.R.S. (Pres. B, 1897 : Council 1891–98), Professor of Chemistry in University College, London. 19 Chester-terrace, Regent's Park, N.W.
1883. ‡Ramsay, Lady. 19 Chester-terrace, Regent's Park, N.W.
1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, W.
1901. ‡Rankin, James, M.A., B.Sc. The University, Glasgow.
1868. *Ransom, Edwin, F.R.G.S. 24 Ashburnham-road, Bedford.
1893. ‡Ransom, W. B., M.D. The Pavement, Nottingham.
1863. ‡Ransom, William Henry, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡Ransome, Arthur, M.A., M.D., F.R.S. (Local Sec. 1861). Sunnyhurst, Deane Park, Bournemouth.
Ransome, Thomas. Hest Bank, near Lancaster.
1889. §Rapkin, J. B. Thrale Hall, Streatham, S.W.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, N.W.
1903. §Rastall, R. H. Christ's College, Cambridge.
1864. ‡Rate, Rev. John, M.A. Fairfield, East Twickenham.
1892. *Rathbone, Miss May. Backwood, Neston, Cheshire.
1874. ‡Ravenstein, E. G., F.R.G.S., F.S.S. (Pres. E, 1891). 2 York-mansions, Battersea Park, S.W.
1889. ‡Rawlings, Edward. Richmond House, Wimbledon Common, Surrey.
1870. ‡Rawlins, G. W. The Hollies, Rainhill, Liverpool.
1887. ‡Rawson, Harry. Earlswood, Ellesmere Park, Eccles, Manchester.
1868. *Rayleigh, The Right Hon. Lord, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. (President, 1884; Trustee, 1883– : Pres. A, 1882; Council, 1878–83; Vice-President, 1904), Professor of Natural Philosophy in the Royal Institution. Terling Place, Witham, Essex.
1895. ‡Raynbird, Hugh, jun. Garrison Gateway Cottage, Old Basing, Basingstoke.
1883. *Rayne, Charles A., M.D., M.R.C.S. St. Mary's Gate, Lancaster.
1897. *Rayner, Edwin Hartree. 19 Tiviot Dale, Stockport.
1896. *Read, Charles H., F.S.A. (Pres. H, 1899). British Museum, W.C.
1902. ‡Reade, R. H. Wilmount, Dunmurry.
1870. ‡Reade, Thomas Mellard, F.G.S. Blundellsands, Liverpool.
1884. §Readman, J. B., D.Sc., F.R.S.E. 4 Lindsay-place, Edinburgh.
1899. ‡Reaster, James William. 68 Linden-grove, Nunhead, S.E.
1852. *Redfern, Professor Peter, M.D. (Pres. D, 1874). 4 Lower-crescent, Belfast.
1892. ‡Redgrave, Gilbert R., Assoc.Inst.C.E. The Elms, Westgate-road, Beckenham, Kent.
1889. ‡Redmayne, J M. Harewood, Gateshead.
1889. ‡Redmayne, Norman. 26 Grey-street, Newcastle-upon-Tyne.
1890. *Redwood, Boverton, F.R.S.E., F.C.S. Wadham Lodge, Wadham-gardens, N.W.
1861. ‡Reed, Sir Edward James, K.C.B., F.R.S. Broadway-chambers, Westminster, S.W.
1889. ‡Reed, Rev. George. Bellingham Vicarage, Bardon Mill, Carlisle.
1891. *Reed, Thomas A. Bute Docks, Cardiff.
1894. *Rees, Edmund S. G. Dunscar, Oaken, near Wolverhampton.
1891. *Rees, I. Treharne, M.Inst.C.E. Blaenypant, near Newport, Monmouthshire.
1888. ‡Rees, W. L. 11 North-crescent, Bedford-square, W.C.
1875. ‡Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.

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Year of Election.

1897. ‡Reeve, Richard A. 22 Shuter-street, Toronto, Canada.
1903. §Reeves, E. A., F.R.G.S. 1 Savile-row, W.
1901. *Reid, Andrew T. 10 Woodside-terrace, Glasgow.
1881. §Reid, Arthur S., M.A., F.G.S. Trinity College, Glenalmond, N.B.
1883. *Reid, Clement, F.R.S., F.L.S., F.G.S. 28 Jermyn-street, S.W.
1903. *Reid, Mrs. E. M., B.Sc. 36 Sarre-road, West Hampstead, N.W.
1892. ‡Reid, E. Waymouth, B.A., M.B., F.R.S., Professor of Physiology in University College, Dundee.
1889. ‡Reid, G., Belgian Consul. Leazes House, Newcastle-upon-Tyne.
1901. *Reid, Hugh. Belmont, Springburn, Glasgow.
1876. ‡Reid, James. 10 Woodside-terrace, Glasgow.
1901. ‡Reid, John. 7 Park-terrace, Glasgow.
1897. §Reid, T. Whitehead, M.D. St. George's House, Canterbury.
1892. ‡Reid, Thomas. University College, Dundee.
1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.
1893. ‡Reinach, Baron Albert von. Frankfort s. M., Prussia.
1875. §Reinold, A. W., M.A., F.R.S. (Council 1890–95), Professor of Physics in the Royal Naval College, Greenwich, S.E.
1863. ‡Renals, E. 'Nottingham Express' Office, Nottingham.
1894. ‡Rendall, Rev. G. H., M.A. Charterhouse, Godalming.
1891. *Rendell, Rev. James Robson, B.A. Whinside, Whalley-road, Accrington.
1903. §Rendle, Dr. A. B. 47 Wimbledon Park-road, Wimbledon.
1885. ‡Rennett, Dr. 12 Golden-square, Aberdeen.
1889. *Rennie, George B. 20 Lowndes-street, S.W.
1867. ‡*Renny, W. W.* 8 *Douglas-terrace, Broughty Ferry, Dundee.*
1883. *Reynolds, A. H. Bank House, 135 Lord-street, Southport.
1871. ‡Reynolds, James Emerson, M.D., D.Sc., F.R.S., Pres.C.S., M.R.I.A. (Pres. B, 1893; Council 1893–99). 29 Camden Hill-court, W.
1900. *Reynolds, Miss K. M. 4 Colinette-road, Putney, S.W.
1870. *Reynolds, Osborne, M.A., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1887), Professor of Engineering in the Owens College, Manchester. 19 Lady Barn-road, Fallowfield, Manchester.
1896. ‡*Reynolds, Richard S.* 73 *Smithdown-lane, Liverpool.*
1896. ‡Rhodes, Albert. Fieldhurst, Liveraidge, Yorkshire.
1877. *Rhodes, John. 360 Blackburn-road, Accrington, Lancashire.
1890. ‡Rhodes, J. M., M.D. Ivy Lodge, Didsbury.
1884. ‡Rhodes, Lieut.-Colonel William. Quebec, Canada.
1899. *Rhys, Professor John, D.Sc. (Pres. H, 1900). Jesus College, Oxford.
1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Riva Muro, 14, Modena, Italy.
1891. ‡Richards, D. 1 St. Andrew's-crescent, Cardiff.
1891. ‡Richards, H. M. 1 St. Andrew's-crescent, Cardiff.
1889. ‡Richards, Professor T. W., Ph.D. Cambridge, Massachusetts, U.S.A.
1869. *Richardson, Charles. 6 The Avenue, Bedford Park, Chiswick, W.
1882. ‡Richardson, Rev. George, M.A. Walcote, Winchester.
1884. *Richardson, George Straker. Isthmian Club, Piccadilly, W.
1889. ‡Richardson, Hugh, M.A. Bootham School, York.
1884. *Richardson, J. Clarke. Derwen Fawr, Swansea.
1896. *Richardson, Nelson Moore, B.A., F.E.S. Montevideo, Chickerell, near Weymouth.
1901. *Richardson, Owen Willans. Trinity College, Cambridge.
1870. ‡Richardson, Ralph, F.R.S.E. 10 Magdala-place, Edinburgh.
1889. ‡Richardson, Thomas, J.P. 7 Windsor-terrace, Newcastle-upon-Tyne.
1876. §Richardson, William Haden. City Glass Works, Glasgow.

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Year of Election.

1891. †Riches, Carlton H. 21 Dumfries-place, Cardiff.
1891. §Riches, T. Harry. 8 Park-grove, Cardiff.
1886. †Richmond, Robert. Heathwood, Leighton Buzzard.
1868. †Ricketts, Charles, M.D., F.G.S. Curdridge, Botley, Hampshire.
1883. *Ridbal, Samuel, D.Sc., F.C.S. 28 Victoria-street, S.W.
1902. §Ridgeway, William, M.A., Professor of Archæology in the University of Cambridge. Fen Ditton, Cambridge.
1894. §Ridley, E. P. (Local Sec. 1895). Burwood, Westerfield-road, Ipswich.
1861. †Ridley, John. 19 Belsize-park, Hampstead, N.W.
1884. †Ridout, Thomas. Ottawa, Canada.
1881. *Rigg, Arthur. 15 Westbourne Park-villas, W.
1883. *Rigg, Edward, M.A. Royal Mint, E.
1892. †Rintoul, D., M.A. Clifton College, Bristol.
*Ripon, The Most Hon. the Marquess of, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S., F.L.S., F.R.G.S. 9 Chelsea Embankment, S.W.
1892. †Ritchie, R. Peel, M.D., F.R.S.E. 1 Melville-crescent, Edinburgh.
1889. †Ritson, U. A. 1 Jesmond-gardens, Newcastle-upon-Tyne.
1903. *Rivers, W. H. R., M.D. St. John's College, Cambridge.
1900. †Rixon, F. W., B.Sc. 79 Green-lane, Heywood, Lancashire.
1898. §Robb, Alfred A. Lisnabreeny House, Belfast.
1902. *Roberts, Bruno. 30 St. George's-square, Regent's Park, N.W.
1887. *Roberts, Evan. 30 St. George's-square, Regent's Park, N.W.
1859. †Roberts, George Christopher. Hull.
1870. *Roberts, Isaac, D.Sc., F.R.S., F.R.A.S., F.G.S. Starfield, Crowborough, Sussex.
1881. †Roberts, R. D., M.A., D.Sc., F.G.S. 4 Regent-street, Cambridge.
1879. †Roberts, Samuel, M.P. The Towers, Sheffield.
1879. †Roberts, Samuel, jun. The Towers, Sheffield.
1896. §Roberts, Thomas J. 33 Serpentine-road, Liscard, Cheshire.
1883. †Robertson, Alexander. Montreal, Canada.
1884. †*Robertson, E. Stanley, M.A.* 43 *Waterloo-road, Dublin.*
1883. †Robertson, George H. Plas Newydd, Llangollen.
1883. †Robertson, Mrs. George H. Plas Newydd, Llangollen.
1897. §Robertson, Sir George S., K.C.S.I. (Pres. E, 1900). 1 Pump-court, Temple, E.C.
1897. †Robertson, Professor J. W. Department of Agriculture, Ottawa, Canada.
1901. *Robertson, Robert, B.Sc., M.Inst.C.E. 154 West George-street, Glasgow.
1892. †Robertson, W. W. 3 Parliament-square, Edinburgh.
1886. *Robinson, C. R. 27 *Elvetham-road, Birmingham.*
1898. §Robinson, Charles E., M.Inst.C.E. Holm Cross, Ashburton, South Devon.
1861. †Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1903. §Robinson, G. H. 1 Weld-road, Southport.
1897. †Robinson, Haynes. St. Giles's Plain, Norwich.
1887. §Robinson, Henry, M.Inst.C.E. 13 Victoria-street, S.W.
1902. §Robinson, Herbert C. Holmfield, Aigburth, Liverpool.
1902. †Robinson, James, M.A., F.R.G.S. Dulwich College, Dulwich, S.E.
1901. §Robinson, John, M.Inst.C.E. 8 Vicarage-terrace, Kendal.
1878. †Robinson, John L. 198 Great Brunswick-street, Dublin.
1895. *Robinson, Joseph Johnson. 8 Trafalgar-road, Birkdale, Southport.
1876. †Robinson, M. E. 6 Park-circus, Glasgow.
1899. *Robinson, Mark, M.Inst.C.E. Overslade, Bilton, near Rugby.

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Year of Election.

1887. ‡Robinson, Richard. Bellfield Mill, Rochdale.
1881. ‡Robinson, Richard Atkinson. 195 Brompton-road, S.W.
1875. *Robinson, Robert, M.Inst.C.E. Beechwood, Darlington.
1884. ‡Robinson, Stillman. Columbus, Ohio, U.S.A.
1901. ‡Robinson, T. Eaton. 33 Cecil-street West, Glasgow.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1891. ‡Robinson, William, Assoc.M.Inst.C.E., Professor of Engineering in University College, Nottingham.
1888. ‡Robottom, Arthur. 3 St. Alban's-villas, Highgate-road, N.W.
1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster, S.W.
1872. *Robson, William. 5 Gillsland-road, Merchiston, Edinburgh.
1890. ‡Rochester, The Right Rev. E. S. Talbot, D.D., Lord Bishop of. Kennington Park, S.E.
1896. ‡*Rock, W. H.* 73 *Park-road East, Birkenhead.*
1896. ‡Rodger, Alexander M. The Museum, Tay Street, Perth.
1885. *Rodger, Edward. 1 Clairmont-gardens, Glasgow.
1885. *Rodriguez, Epifanio. New Adelphi Chambers, 6 Robert-street, Adelphi, W.C.
1866. ‡Roe, Sir Thomas. Grove-villas, Litchurch.
1898. ‡Rogers, Bertram, M.D. (Local Sec. 1898.) 11 York-place, Clifton, Bristol.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1890. *Rogers, L. J., M.A., Professor of Mathematics in Yorkshire College, Leeds. 15 Regent Park-avenue, Leeds.
1883. ‡Rogers, Major R. Alma House, Cheltenham.
1882. §Rogers, Rev. Canon Saltren, M.A. Tresleigh, St. Austell, Cornwall.
1884. *Rogers, Walter. Hill House, St. Leonards.
1889. ‡Rogerson, John. Croxdale Hall, Durham.
1897. ‡Rogerson, John. Barrie, Ontario, Canada.
1876. ‡Rollit, Sir A. K., M.P., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. Thwaite House, Cottingham, East Yorkshire.
1891. ‡Rönnfeldt, W. 43 Park-place, Cardiff.
1894. *Rooper, T. Godolphin. 12 Cumberland-place, Southampton.
1881. *Roper, W. O. Beechfield, Yealand Convers, Carnforth.
1855. *Roscoe, Sir Henry Enfield, B.A., Ph.D., LL.D., D.C.L., F.R.S. (President, 1887; Pres. B, 1870, 1884; Council 1874-81; Local Sec. 1861). 10 Bramham-gardens, S.W.
1883. *Rose, J. Holland, M.A. 11 Endlesham-road, Balham, S.W.
1894. *Rose, T. K., D.Sc, Chemist and Assayer to the Royal Mint. Royal Mint, E.
1900. ‡Rosenhain, Walter, B.A. 185 Monument-road, Edgbaston, Birmingham.
1885. ‡Ross, Alexander. Riverfield, Inverness.
1887. ‡Ross, Edward. Marple, Cheshire.
1859. *Ross, Rev. James Coulman. Wadworth Hall, Doncaster.
1902. §Ross, John Callender. 46 Holland-street, Campden Hill, W.
1901. ‡Ross, Major Ronald, C.B., F.R.S. 36 Bentley-road, Liverpool.
1869. *Rosse, The Right Hon. the Earl of, K.P., B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland.
1891. *Roth, H. Ling. 32 Prescot-street, Halifax, Yorkshire.
1893. ‡Rothera, G. B. Sherwood Rise, Nottingham.
1865. *Rothera, George Bell. Hazlewood, Forest-grove, Nottingham.
1901. *Rottenburg, Paul, LL.D. Care of Messrs. Leister, Bock, & Co., Glasgow.
1899. *Round, J. C., M.R.C.S. 19 Crescent-road, Sydenham Hill, S.E.
1884. *Rouse, M. L. Hollybank, Hayne-road, Beckenham.

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Year of Election.

1901. ‡Rouse, W. H. D. Perse School, Cambridge.
1861. ‡ROUTH, EDWARD J., M.A., D.Sc., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1883. ‡Rowan, Frederick John. 134 St. Vincent-street, Glasgow.
1903. *Rowe, Arthur W., M.B., F.G.S. 1 Cecil-street, Margate.
1877. ‡ROWE, J. BROOKING, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1890. ‡Rowley, Walter, F.S.A. Alderhill, Meanwood, Leeds.
1881. *ROWNTREE, JOHN S. Mount-villas, York.
1881. *Rowntree, Joseph. 38 St. Mary's, York.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1885. ‡Roy, John. 33 Belvidere-street, Aberdeen.
1899. ‡Rubie, G. S. Belgrave House, Folkestone-road, Dover.
1875. *RÜCKER, Sir A. W., M.A., D.Sc., F.R.S., Principal of the University of London (PRESIDENT, 1901; TRUSTEE, 1898– ; GENERAL TREASURER, 1891–98; Pres. A, 1894; Council 1888–91). 19 Gledhow-gardens, South Kensington, S.W.
1892. §Rücker, Mrs. Levetleigh, Dane-road, St. Leonards-on-Sea.
1869. §RUDLER, F. W., F.G.S. 18 St. George's-road, Kilburn, N.W.
1901. *Rudorf, C. C. G. 26 Weston-park, Crouch End, N.
1882. ‡Rumball, Thomas, M.Inst.C.E. 1 Victoria-villas, Brondesbury, N.W.
1896. *Rundell, T. W., F.R.Met.Soc. 25 Castle-street, Liverpool.
1887. ‡*Ruscoe, John. Ferndale, Gee Cross, near Manchester.*
1889. ‡Russell, The Right Hon. Earl. Amberley Cottage, Maidenhead.
1875. *Russell, The Hon. F. A. R. Dunrozel, Haslemere.
1884. ‡*Russell, George.* 13 *Church-road, Upper Norwood, S.E.*
Russell, John. 39 Mountjoy-square, Dublin.
1890. ‡Russell, Sir J. A., LL.D. Woodville, Canaan-lane, Edinburgh.
1883. *Russell, J. W. 131 Woodstock-road, Oxford.
1852. *Russell, Norman Scott. Arts Club, Dover-street, W.
1876. ‡Russell, Robert, F.G.S. 1 Sea View, St. Bees, Carnforth.
1886. ‡Russell, Thomas H. 3 Newhall-street, Birmingham.
1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., V.P.C.S. (Pres. B, 1873: Council 1873–80). 34 Upper Hamilton-terrace, St. John's Wood, N.W.
1886. ‡Rust, Arthur. Eversleigh, Leicester.
1897. ‡Rutherford, A. Toronto, Canada.
1891. ‡*Rutherford, George. Dulwich House, Pencisely-road, Cardiff.*
1887. ‡*Rutherford, William. 7 Vine-grove, Chapman-street, Hulme, Manchester.*
1889. ‡Ryder, W. J. H. 52 Jesmond-road, Newcastle-upon-Tyne.
1897. ‡Ryerson, G. S., M.D. Toronto, Canada.
1898. §Ryland, C. J. Southerndon House, Clifton, Bristol.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.

1903. §Sadler, M. E., LL.D., Professor of Education in Owens College, Manchester.
1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. 186 Aldersgate-street, E.C.
1903. §Sagar, J. The Poplars, Savile Park, Halifax.
1881. ‡Salkeld, William. 4 Paradise-terrace, Darlington.
1857. ‡SALMON, Rev. GEORGE, D.D., D.C.L., LL.D., F.R.S. (Pres. A, 1878), Provost of Trinity College, Dublin.
1873. *Salomons, Sir David, Bart., F.G.S. Broomhill, Tunbridge Wells.
1887. ‡Samson, C. L. Carmona, Kersal, Manchester.

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Year of Election.

1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1901. §Samuel, John S., F.R.S.E. City Chambers, Glasgow.
1894. ‡Samuelson, The Right Hon. Sir Bernhard, Bart., F.R.S., M.Inst.C.E. 56 Prince's-gate, S.W.
1883. ‡Sanderson, Surgeon-General Alfred. East India United Service Club, St. James's-square, S.W.
1893. ‡Sanderson, F. W., M.A. The School, Oundle.
1872. §Sanderson, Sir J. S. Burdon, Bart., M.D., D.Sc., LL.D., D.C.L., F.R.S., F.R.S.E. (President, 1893; Pres. D, 1889; Council 1877–84). 64 Banbury-road, Oxford.
1883. ‡Sanderson, Lady Burdon. 64 Banbury-road, Oxford.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1896. §Saner, John Arthur, Assoc.M.Inst.C.E. Highfield, Northwich.
1896. ‡Saner, Mrs. Highfield, Northwich.
1892. §Sang, William D. Tylehurst, Kirkcaldy, Fife.
1903. §Sankey, Captain H. R., R.E. Bawmore, Bilton, Rugby.
1886. §Sankey, Percy E. 44 Russell-square, W.C.
1896. *Sargant, Miss Ethel. Quarry Hill, Reigate.
1896. ‡Sargant, W. L. Quarry Hill, Reigate.
1901. ‡Sarruf, N. Y. 'Al Mokattam,' Cairo.
1886. ‡Sauborn, John Wentworth. Albion, New York, U.S.A.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1900. *Saunder, S. A. Fir Holt, Crowthorne, Berks.
1868. ‡Saunders, A., M.Inst.C.E. King's Lynn.
1886. ‡Saunders, C. T. Temple-row, Birmingham.
1903. *Saunders, Miss E. R. Newnham College, Cambridge.
1881. ‡Saunders, Howard, F.L.S., F.Z.S. 7 Radnor-place, W.
1883. ‡Saunders, Rev. J. C. Cambridge.
1846. ‡Saunders, Trelawney W., F.R.G.S. 3 Elmfield-on-the-Knowles, Newton Abbot, Devon.
1884. ‡Saunders, Dr. William. Experimental Farm, Ottawa, Canada.
1891. ‡*Saunders, W. H. R. Llanishen, Cardiff.*
1884. ‡Saunderson, C. E. 26 St. Famille-street, Montreal, Canada.
1887. ‡Savage, Rev. Canon E. B., M.A., F.S.A. St. Thomas' Vicarage, Douglas, Isle of Man.
1883. ‡Savage, W. W. 109 St. James's-street, Brighton.
1883. ‡Savery, G. M., M.A. The College, Harrogate.
1901. §Sawers, W. D. 1 Athole Gardens-place, Glasgow.
1887. §Sayce, Rev. A. H., M.A., D.D. (Pres. H, 1887), Professor of Assyriology in the University of Oxford. Queen's College, Oxford.
1884. ‡Sayre, Robert H. Bethlehem, Pennsylvania, U.S.A.
1883. *Scarborough, George. Whinney Field, Halifax, Yorkshire.
1903. §Scarisbrick, Sir Charles, J.P. Scarisbrick Lodge, Southport.
1903. §Scarisbrick, Lady. Scarisbrick Lodge, Southport.
1879. *Schäfer, E. A., LL.D., F.R.S., M.R.C.S. (Gen. Sec. 1895–1900; Pres. I, 1894; Council 1887–93), Professor of Physiology in the University of Edinburgh.
1868. *Scharff, Robert F., Ph.D., B.Sc., Keeper of the Natural History Department, Museum of Science and Art, Dublin.
1880. *Schemmann, Louis Carl. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)
1892. ‡*Schloss, David F.* 1 *Knaresborough-place, S.W.*
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1887. ‡*Schofield, T. Thornfield, Talbot-road, Old Trafford, Manchester.*
1883. ‡Schofield, William. Alma-road, Birkdale, Southport.
1885. §Scholes, L. Arncliffe, Trinity-road, Sale, Cheshire.

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Year of Election.

1873. *Schuster, Arthur, Ph.D., F.R.S., F.R.A.S. (Pres. A, 1892: Council 1887–93), Professor of Physics in the Owens College. Kent House, Victoria Park, Manchester.
1847. *Sclater, Philip Lutley, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S. (General Secretary 1876–81; Pres. D, 1875; Council 1864–67, 1872–75). Odiham Priory, Winchfield.
1883. *Sclater, W. Lutley, M.A., F.Z.S. South African Museum, Cape Town.
1867. ‡Scott, Alexander. Clydesdale Bank, Dundee.
1881. *Scott, Alexander, M.A., D.Sc., F.R.S., Sec.C.S. Royal Institution, Albemarle-street, W.
1878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.
1881. ‡Scott, Miss Charlotte Angas, D.Sc. Bryn Mawr College, Pennsylvania, U.S.A.
1889. *Scott, D. H., M.A., Ph.D., F.R.S., F.L.S. (General Secretary, 1900–03; Pres. K, 1896). The Old Palace, Richmond, Surrey.
1885. ‡Scott, George Jamieson. Bayview House, Aberdeen.
1857. *Scott, Robert H., M.A., D.Sc., F.R.S., F.R.Met.S. 6 Elm Park-gardens, S.W.
1884. *Scott, Sydney C. 28 The Avenue, Gipsy Hill, S.E.
1902. §Scott, William R. The University, St. Andrew's, Scotland.
1895. ‡Scott-Elliot, Professor G. F., M.A., B.Sc., F.L.S. Ainslea, Scottounhill, Glasgow.
1883. ‡Scrivener, Mrs. Haglis House, Wendover.
1895. §Scull, Miss E. M. L. The Pines, 10 Langland-gardens, Hampstead, N.W.
1890. ‡Searle, G. F. C., M.A. 20 Trumpington-street, Cambridge.
1859. ‡Seaton, John Love. The Park, Hull.
1880. ‡Sedgwick, Adam, M.A., F.R.S. (Pres. D, 1899). 4 Cranmer-road, Cambridge.
1861. *Seeley, Harry Govier, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geology in King's College, London. 25 Palace Gardens-terrace, Kensington, W.
1891. ‡Selby, Arthur L., M.A., Assistant Professor of Physics in University College, Cardiff.
1893. ‡Selby-Bigge, L. A., M.A. Charity Commission, Whitehall, S.W.
1855. ‡Seligman, H. L. 27 St. Vincent-place, Glasgow.
1879. ‡Selim, Adolphus. 21 Mincing-lane, E.C.
1897. ‡Selous, F. C., F.R.G.S. Alpine Lodge, Worplesden, Surrey.
1885. ‡Semple, Dr. A. United Service Club, Edinburgh.
1888. *Senier, Alfred, M.D., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
1888. *Sennett, Alfred R., A.M.Inst.C.E. 304 King's-road, Chelsea, S.W.
1901. ‡Service, Robert. Janefield Park, Maxwelltown, Dumfries.
1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.
1892. ‡Seton, Miss Jane. 37 Candlemaker-row, Edinburgh.
1895. *Seton-Karr, H. W. 31 Lingfield-road, Wimbledon, Surrey.
1892. *Seward, A. C., M.A., F.R.S., F.G.S. (Pres. K, 1903; Council 1901– ; Local Secretary 1904). Westfield, Huntingdon-road, Cambridge.
1891. ‡*Seward, Edwin.* 55 *Newport-road, Cardiff.*
1868. ‡Sewell, Philip E. Catton, Norwich.
1899. §Seymour, Henry J., B.A., F.G.S. 16 Wellington-road, Dublin.
1891. ‡Shackell, E. W. 191 Newport-road, Cardiff.
1888. ‡*Shackles, Charles F. Hornsea, near Hull.*

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Year of Election.

1902. ‡SHAFTESBURY, The Right Hon. the Earl of, D.L. Belfast Castle, Belfast.
1867. ‡Shanks, James. Dens Iron Works, Arbroath, N.B.
1881. ‡Shann, George, M.D. Petergate, York.
1878. ‡SHARP, DAVID, M.A., M.B., F.R.S., F.L.S. Museum of Zoology, Cambridge.
1896. ‡Sharp, Mrs. E. 65 Sankey-street, Warrington.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1886. ‡Sharp, T. B. French Walls, Birmingham.
1883. ‡Sharples, Charles H. 7 Fishergate, Preston.
1870. ‡Shaw, Duncan. Cordova, Spain.
1896. ‡Shaw, Frank. Elleralie, Aigburth-drive, Liverpool.
1870. ‡Shaw, John. 21 St. James's-road, Liverpool.
1891. ‡Shaw, Joseph. 1 Temple-gardens, E.C.
1889. *Shaw, Mrs. M. S., B.Sc. Sydenham Damard Rectory, Tavistock.
1883. *SHAW, W. N., M.A., D.Sc., F.R.S. (Council 1895–1900). Meteorological Office, Victoria-street, S.W.
1883. ‡Shaw, Mrs. W. N. 10 Moreton-gardens, South Kensington, S.W.
1903. §Shaw-Phillips, T. 19 Camden-crescent, Bath.
1891. ‡Sheen, Dr. Alfred. 23 Newport-road, Cardiff.
1878. ‡Shelford, William, M.Inst.C.E. 35A Great George-street, S.W.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1881. ‡SHENSTONE, W. A., F.R.S. Clifton College, Bristol.
1885. ‡Shepherd, Rev. Alexander. Ecclesmechen, Uphall, Edinburgh.
1890. ‡Shepherd, J. 80 Prince of Wales-mansions, Battersea, S.W.
1883. ‡Shepherd, James. Birkdale, Southport.
1900. §Sheppard, Thomas, F.G.S. The Municipal Museum, Hull.
1883. ‡Sherlock, David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Mrs. David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Rev. Edgar. Bentham Rectory, *vid* Lancaster.
1896. §SHERRINGTON, C. S., M.D., F.R.S., Professor of Physiology in the University of Liverpool. 16 Grove-park, Liverpool.
1888. *Shickle, Rev. C. W., M.A., F.S.A. St. John's Hospital, Bath.
1886. ‡Shield, Arthur H. 35A Great George-street, S.W.
1892. ‡Shields, John, D.Sc., Ph.D. Dolphingston, Tranent, Scotland.
1901. ‡Shields, Thomas, M.A., B.Sc. Englefield Green, Surrey.
1902. *Shillington, T. Foulkes, J.P. Dromart, Antrim-road, Belfast.
1883. *Shillitoe, Buxton, F.R.C.S. 2 Frederick-place, Old Jewry, E.C.
1887. *SHIPLEY, ARTHUR E., M.A. (LOCAL TREASURER 1904.) Christ's College, Cambridge.
1889. ‡Shipley, J. A. D. Saltwell Park, Gateshead.
1885. ‡Shirras, G. F. 16 Carden-place, Aberdeen.
1883. ‡Shone, Isaac. Pentrefelin House, Wrexham.
1870. *SHOOLBRED, J. N., B.A., M.Inst.C.E. 47 Victoria-street, S.W.
1888. ‡Shoppee, C. H. 22 John-street, Bedford-row, W.C.
1897. ‡SHORE, Dr. LEWIS E. St. John's College, Cambridge.
1875. ‡SHORE, THOMAS W., F.G.S. 157 Bedford-hill, Balham, S.W.
1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. Heathfield, Alleyn Park, Dulwich, S.E.
1901. ‡Short, Peter M., B.Sc. 5 Richmond-terrace, Old Trafford, Manchester.
1897. ‡Shortt, Professor Adam, M.A. Queen's University, Kingston, Ontario, Canada.
1889. ‡Sibley, Walter K., B.A., M.B. 8 Duke Street-mansions, Grosvenor-square, W.
1883. ‡Sibly, Miss Martha Agnes. Flook House, Taunton.

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Year of Election.

1902. §Siddons, A. W. Harrow-on-the-Hill, Middlesex.
1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.
1883. *Sidebotham, James Nasmyth. Parkfield, Altrincham, Cheshire.
1877. *Sidebotham, Joseph Watson. Merlewood, Bowdon, Cheshire.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1873. *Siemens, Alexander, M.Inst.C.E. 7 Airlie-gardens, Campden Hill, W.
1903. *Silberrad, Dr. Oswald. Experimental Establishment, Royal Arsenal, Woolwich.
1859. ‡Sim, John. Hardgate, Aberdeen.
1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1898. ‡Simmons, Henry. Kingsland House, Whiteladies-road, Clifton, Bristol.
1862. ‡Simms, James. 138 Fleet-street, E.C.
1874. ‡Simms, William. Upper Queen-street, Belfast.
1876. ‡*Simon, Frederick.* 24 *Sutherland-gardens, W.*
1847. ‡Simon, Sir John, K.C.B., M.D., D.C.L., F.R.S. (Council 1870–72). 40 Kensington-square, W.
1901. ‡Simpson, Rev. A., B.Sc., F.G.S. 28 Myrtle-park, Crosshill, Glasgow.
1871. *Simpson, Alexander R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.
1887. ‡Simpson, F. Estacion Central, Buenos Ayres.
1859. ‡Simpson, John. Maykirk, Kincardineshire.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1901. *Simpson, J. Y., M.A., D.Sc., F.R.S.E. 52 Queen-street, Edinburgh.
1894. §Simpson, Thomas, F.R.G.S. Fennymere, Castle Bar, Ealing, W.
1883. ‡Simpson, Walter M. 7 York-road, Birkdale, Southport.
1896. *Simpson, W., F.G.S. The Gables, Halifax.
1887. ‡Sinclair, Dr. 268 Oxford-street, Manchester.
1874. ‡Sinclair, Right Hon. Thomas (Local Sec. 1874). Dunedin, Belfast.
1897. ‡Sinnott, James. Bank of England-chambers, 12 Broad-street, Bristol.
1864. *Sircar, The Hon. Mahendra Lal, M.D., C.I.E. 51 Sankaritola, Calcutta.
1892. ‡Sisley, Richard, M.D. 1 Park-row, S.W.
1902. §Skeffington, J. B. Waterford.
1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.
1885. ‡Skinner, Provost. Inverurie, N.B.
1898. ‡Skinner, Sidney, M.A. (Local Secretary 1904). Cromwell House, Trumpington-road, Cambridgeshire.
1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.
1884. ‡Slattery, James W. 9 Stephen's-green, Dublin.
1877. ‡Sleeman, Rev. Philip, L.Th., F.R.A.S. 65 Pembroke-road, Clifton, Bristol.
1901. §Slocombe, James. Redland House, Fitzalan, Cardiff.
1849. ‡Sloper, George Elgar. Devizes.
1887. §Small, Evan W., M.A., B.Sc., F.G.S. The Mount, Radbourne-street, Derby.
1887. §Small, William. Lincoln-circus, The Park, Nottingham.
1903. §Smallman, Raleigh S. Carlton House, Herne Hill, S.E.
1889. *Smart, Professor William, LL.D. Nunholme, Dowanhill, Glasgow.
1902. §Smedley, Miss Ida. Sheepcote, Wooburn Green, near Maidenhead.
1898. ‡Smeeth, W. F., M.A., F.G.S. Mysore, India.
1876. ‡Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1890. ‡Smethurst, Charles. Palace House, Harpurhey, Manchester.

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Year of Election.

1876. ‡Smieton, James. Panmure Villa, Broughty Ferry, Dundee.
1867. ‡Smieton, Thomas A. Panmure Villa, Broughty Ferry, Dundee.
1892. ‡Smith, Alexander, B.Sc., Ph.D., F.R.S.E. The University, Chicago, Illinois, U.S.A.
1897. ‡Smith, Andrew, Principal of the Veterinary College, Toronto, Canada.
1901. *Smith, Miss Annie Lorrain. 20 Talgarth-road, West Kensington, W.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, S.W.
1887. ‡Smith, Bryce. Rye Bank, Chorlton-cum-Hardy, Manchester.
1873. ‡Smith, C. Sidney College, Cambridge.
1887. *Smith, Charles. 739 Rochdale-road, Manchester.
1889. *Smith, Professor C. Michie, B.Sc., F.R.S.E., F.R.A.S. The Observatory, Kodaikanal, South India.
1886. ‡*Smith, Edwin. 33 Wheeley's-road, Edgbaston, Birmingham.*
1886. *Smith, Mrs. Emma. Hencotes House, Hexham.
1886. ‡Smith, E. Fisher, J.P. The Priory, Dudley.
1900. §Smith, E. J. Grange House, Westgate Hill, Bradford.
1886. ‡Smith, E. O. Council House, Birmingham.
1892. ‡Smith, E. Wythe. 66 College-street, Chelsea, S.W.
1897. ‡Smith, Sir Frank. 54 King-street East, Toronto, Canada.
1901. §Smith, F. B. Care of A. Croxton Smith, Esq., Burlington House, Wandle-road, Upper Tooting, S.W.
1866. *Smith, F. C. Bank, Nottingham.
1885. ‡Smith, Rev. G. A., M.A. 22 Sardinia-terrace, Glasgow.
1897. ‡Smith, G. Elliot, M.D. St. John's College, Cambridge.
1860. *Smith, Heywood, M.A., M.D. 25 Welbeck-street, Cavendish-square, W.
1903. §Smith, H. B. Lees. Ruskin Hall, Oxford.
1870. ‡*Smith, H. L. Crabwall Hall, Cheshire.*
1889. *Smith, H. Llewellyn, C.B., B.A., B.Sc., F.S.S. 4 Harcourt-buildings, Inner Temple, E.C.
1888. ‡Smith, H. W. Owens College, Manchester.
1876. *Smith, J. Guthrie. 5 Kirklee-gardens, Kelvinside, Glasgow.
1902. ‡Smith, J. Lorrain, M.D., Professor of Pathology in Queen's College, Belfast. Westbourne, Windsor-avenue, Belfast.
1901. ‡Smith, J. Parker, M.P. Jordanhill, Glasgow.
1885. ‡Smith, Rev. James, B.D. Manse of Newhills, N.B.
1903. §Smith, James. Pinewood, Crathes.
1876. Smith, John Peter George. Sweyney Cliff, Coalport, Iron Bridge, Shropshire.
1883. ‡Smith, M. Holroyd. Royal Insurance-buildings, Crossley-street, Halifax.
1885. ‡Smith, Robert H., Assoc.M.Inst.C.E. Ellerslie, Sutton, Surrey.
1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.
1873. ‡Smith, Sir Swire. Lowfield, Keighley, Yorkshire.
1867. ‡Smith, Thomas. Poole Park Works, Dundee.
1894. §Smith, T. Walrond. Care of H. E. P. Cottrell, Esq., 92 Cavendish-road, Balham, S.W.
1892. ‡Smith, Walter A. 120 Princes-street, Edinburgh.
1885. *‡*Smith, Watson. University College, Gower-street, W.C.*
1896. *Smith, Rev. W. Hodson. Newquay, Cornwall.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1876. ‡Smith, William. 12 Woodside-place, Glasgow.
1883. ‡Smithells, Arthur, B.Sc., F.R.S. (Local Sec. 1890), Professor of Chemistry in the Yorkshire College, Leeds.
1883. ‡Smithson, Edward Walter. 13 Lendal, York.
1883. ‡Smithson, Mrs. 13 Lendal, York.

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Year of Election.

1882. †Smithson, T. Spencer. Facit, Rochdale.
1874. †Smoothy, Frederick. Bocking, Essex.
1857. *Smyth, John, M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1888. *Snape, H. Lloyd, D.Sc., Ph.D. Balholm, Lathom-road, Southport.
1878. §Snell, H. Saxon. 22 Southampton-buildings, W.C.
1889. †Snell, W. H. Lancaster Lodge, Amersham-road, Putney, S.W.
1898. †Snook, Miss L. B. V. 13 Clare-road, Cotham, Bristol.
1879. *Sollas, W. J., M.A., D.Sc., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1900; Council 1900-03), Professor of Geology in the University of Oxford. 173 Woodstock-road, Oxford.
1892. *Somervail, Alexander. The Museum, Torquay.
1900. *Somerville, W. Board of Agriculture, Whitehall, S.W.
1859. *Sorby, H. Clifton, LL.D., F.R.S., F.G.S. (Pres. C, 1880; Council 1879-86; Local Sec. 1879). Broomfield, Sheffield.
1879. *Sorby, Thomas W. Storthfield, Ranmoor, Sheffield.
1901. †Sorley, Robert. The Firs, Partickill, Glasgow.
1888. †Sorley, Professor W. R., M.A. Trinity College, Cambridge.
1903. §Soulby, R. M. Sea Holm, Westbourne-road, Birkdale, Lancashire.
1886. †Southall, Alfred. Carrick House, Richmond Hill-road, Birmingham.
1903. §Southall, H. T. The Graig, Ross, Herefordshire.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1887. §Sowerbutts, Eli, F.R.G.S. 16 St. Mary's Parsonage, Manchester.
1883. †Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.
1890. †Spark, F. R. 29 Hyde-terrace, Leeds.
1893. *Speak, John. Kirton Grange, Kirton, near Boston.
1887. †*Spencer, F. M. Fernhill, Knutsford.*
1884. †Spencer, John, M.Inst.M.E. Globe Tube Works, Wednesbury.
1889. *Spencer, John. Newbiggin House, Kenton, Newcastle-upon-Tyne.
1891. *Spencer, Richard Evans. The Old House, Llandaff.
1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen-park, Highbury, N.
1894. †Spiers, A. H. 21 Bernard-street, Russell-square, W.C.
1864. *Spiller, John, F.C.S. 2 St. Mary's-road, Canonbury, N.
1864. *Spottiswoode, W. Hugh, F.C.S. 107 Sloane-street, S.W.
1854. *Sprague, Thomas Bond, M.A., LL.D., F.R.S.E. 29 Buckingham-terrace, Edinburgh.
1883. †Spratling, W. J., B.Sc., F.G.S. Maythorpe, 74 Wickham-road, Brockley, S.E.
1897. §Squire, W. Stevens, Ph.D. Clarendon House, 30 St. John's Wood Park, N.W.
1888. *Stacy, J. Sargeant. 164 Shoreditch, E.C.
1897. †Stafford, Joseph. Morrisburg, Ontario, Canada.
1903. §Stallworthy, Rev. George B. The Manse, Hindhead, Haslemere, Surrey.
1884. †Stancoffe, Frederick. Dorchester-street, Montreal, Canada.
1892. †Stanfield, Richard, Assoc.M.Inst.C.E., F.R.S.E., Professor of Engineering in the Heriot Watt College, Edinburgh. 49 Mayfield-road, Edinburgh.
1883. *Stanford, Edward, jun., F.R.G.S. Thornbury, High-street, Bromley, Kent.
1881. *Stanley, William Ford, F.G.S. Cumberlow, South Norwood, S.E.
1883. †Stanley, Mrs. Cumberlow, South Norwood, S.E.
1894. *Stansfield, Alfred, D.Sc. McGill University, Montreal, Canada.
1900. *Stansfield, H., B.Sc. Municipal Technical School, Blackburn.
Stapleton, M. H., M.B., M.R.I.A. 1 Mountjoy-place, Dublin.

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Year of Election.

1899. ‡STARLING, E. H., M.D., F.R.S., Professor of Physiology in University College, London. 8 Park-square West, N.W.
1876. ‡*Starling, John Henry, F.C.S.* 32 *Craven-street, Strand, W.C.*
1899. §Statham, William. The Redings, Totteridge, Herts.
1898. †Stather, J. W., F.G.S. 16 Louis-street, Hull.
Staveley, T. K. Ripon, Yorkshire.
1894. ‡Stavert, Rev. W. J., M.A. Burnsall Rectory, Skipton-in-Craven. Yorkshire.
1873. *Stead, Charles. Red Barns, Freshfield, Liverpool.
1900. *Stead, J. E., F.R.S. Laboratory and Assay Office, Middlesbrough.
1881. ‡Stead, W. H. Orchard-place, Blackwall, E.
1881. ‡Stead, Mrs. W. H. Orchard-place, Blackwall, E.
1884. ‡Stearns, Sergeant P. U.S. Consul-General, Montreal, Canada.
1892. *STEBBING, Rev. THOMAS R. R., M.A., F.R.S. Ephraim Lodge, The Common, Tunbridge Wells.
1896. *Stebbing, W. P. D., F.G.S. 169 Gloucester-terrace, W.
1891. ‡*Steeds, A. P.* 15 *St. Helen's-road, Swansea.*
1884. ‡Stephen, George. 140 Drummond-street, Montreal, Canada.
1884. ‡Stephen, Mrs. George. 140 Drummond-street, Montreal, Canada.
1884. *Stephens, W. Hudson. Low-Ville, Lewis County, New York, U.S.A.
1902. §Stephenson, G. Cuilin, Glasnevin, Dublin.
1879. *STEPHENSON, Sir HENRY, J.P. The Glen, Sheffield.
1901. ‡Steven, William. 420 Sauchiehall-street, Glasgow.
1901. ‡Steven, Mrs. W. 420 Sauchiehall-street, Glasgow.
1880. *Stevens, J. Edward, LL.B. Le Mayals, Blackpill, R.S.O.
1900. ‡STEVENS, FREDERICK (Local Sec. 1900). Town Clerk's Office, Bradford.
1892. ‡Stevenson, D. A., B.Sc., F.R.S.E., M.Inst.C.E. 84 George-street, Edinburgh.
1863. *STEVENSON, JAMES C., M.P. Eltham Court, Eltham, Kent.
1890. *Steward, Rev. Charles J., F.R.M.S. The Cedars, Anglesea-road, Ipswich.
1885. *Stewart, Rev. Alexander, M.D., LL.D. Murtle, Aberdeen.
1864. ‡STEWART, CHARLES, M.A., F.R.S., F.L.S., Hunterian Professor of Anatomy and Conservator of the Museum, Royal College of Surgeons, Lincoln's Inn-fields, W.C.
1892. ‡*Stewart, C. Hunter.* 3 *Carlton-terrace, Edinburgh.*
1885. ‡Stewart, David. Banchory House, Aberdeen.
1886. *Stewart, Duncan. 14 Windsor-terrace West, Kelvinside, Glasgow.
1875. *Stewart, James, B.A., F.R.C.P.Ed. Dunmurry, Sneyd Park, near Clifton, Gloucestershire.
1901. *Stewart, John Joseph, M.A., B.Sc. 35 Stow Park-avenue, Newport, Monmouthshire.
1892. ‡Stewart, Samuel. Knocknairn, Bagston, Greenock.
1901. ‡Stewart, Thomas. St. George's-chambers, Cape Town.
1901. ‡Stewart, Walter, M.A., D.Sc. Gartsherrie, Coatbridge.
1901. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1867. ‡Stirling, Dr. D. Perth.
1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Owens College, Manchester.
1867. *Stirrup, Mark, F.G.S. Stamford-road, Bowdon, Cheshire.
1901. *Stobo, Thomas. Somerset House, Garelochhead, Dumbartonshire, N.B.
1865. *Stock, Joseph S. St. Mildred's, Walmer.
1890. ‡Stockdale, R. The Grammar School, Leeds.
1883. *STOCKER, W. N., M.A. Brasenose College, Oxford.

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Year of Election.

1898. ‡Stoddart, F. Wallis, F.I.C. Grafton Lodge, Sneyd Park, Bristol.
1898. *Stokes, Professor George J., M.A. Riversdale, Sunday's Well, Cork.
1887. ‡Stone, E. D., F.C.S. Rose Lea, Alderley Edge, Cheshire.
1892. *Stone, F. J. Radley College, Abingdon.
1886. ‡Stone, Sir J. Benjamin, M.P. The Grange, Erdington, Birmingham.
1886. ‡Stone, J. H. Grosvenor-road, Handsworth, Birmingham.
1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 3 Dr. Johnson's-buildings, Temple, E.C.
1876. ‡Stone, Octavius C., F.R.G.S. Rothbury House, Westcliff-gardens, Bournemouth.
1857. ‡Stoney, Bindon B., LL.D., F.R.S., M.Inst.C.E., M.R.I.A., Engineer of the Port of Dublin. 14 Elgin-road, Dublin.
1895. *Stoney, Miss Edith A. 30 Ledbury-road, Bayswater, W.
1878. *Stoney, G. Gerald. Oakley, Heaton-road, Newcastle-upon-Tyne.
1861. *Stoney, George Johnstone, M.A., D.Sc., F.R.S., M.R.I.A. (Pres. A, 1897). 30 Ledbury-road, Bayswater, W.
1903. *Stopes, Miss Marie, B.Sc. 25 Denning-road, Hampstead, N.W.
1883. ‡Stopes, Mrs. 25 Denning-road, Hampstead, N.W.
1887. *Storey, H. L. Bailrigg, Lancaster.
1884. §Storrs, George H. Gorse Hall, Stalybridge.
1888. *Stothert, Percy K. Woodley Grange, Bradford-on-Avon, Wilts.
1874. ‡*Stott, William. Scar Bottom, Greetland, near Halifax, Yorkshire.*
1871. *Strachey, Lieut.-General Sir Richard, R.E., G.C.S.I., LL.D., F.R.S., F.R.G.S., F.L.S., F.G.S. (Pres. E, 1875; Council, 1871–75). 69 Lancaster-gate, Hyde Park, W.
1881. ‡Strahan, Aubrey, M.A., F.R.S., F.G.S. Geological Museum, Jermyn-street, S.W.
1863. ‡Straker, John. Wellington House, Durham.
1882. ‡Strange, Rev. Canon Cresswell, M.A. The College, Worcester.
1898. ‡Strangeways, C. Fox. Leicester.
1881. ‡Strangeways, C. Fox, F.G.S. Geological Museum, Jermyn-street, S.W.
1889. ‡Streatfeild, H. S., F.G.S. Ryhope, near Sunderland.
1879. ‡Strickland, Sir Charles W., Bart., K.C.B. Hildenley-road, Malton.
1884. ‡Stringham, Irving. The Univereity, Berkeley, California, U.S.A.
1883. §Strong, Henry J., M.D. Colonnade House, The Steyne, Worthing.
1898. *Strong, W. M. 3 Champion-park, Denmark Hill, S.E.
1887. *Stroud, H., M.A., D.Sc., Professor of Physics in the College of Science, Newcastle-upon-Tyne.
1887. *Stroud, William, D.Sc., Professor of Physics in the Yorkshire College, Leeds.
1876. *Stuart, Charles Maddock, M.A. St. Dunstan's College, Catford, S.E.
1872. *Stuart, Rev. Edward A., M.A. 5 Prince's-square, W.
1884. ‡Stuart, Dr. W. Theophilus. 183 Spadina-avenue, Toronto, Canada.
1892. ‡Stuart-Gray, Hon. Morton, M.A., F.G.S. 2 Belford-park, Edinburgh.
1896. ‡Stubbs, Miss. Torrisholme, Aigburth-drive, Sefton Park, Liverpool.
1885. ‡Stump, Edward C. 16 Herbert-street, Moss Side, Manchester.
1897. ‡Stupart, R. F. The Observatory, Toronto, Canada.
1879. *Styring, Robert. Brinkcliffe Tower, Sheffield.
1891. *Sudborough, Professor J. J., Ph.D., D.Sc. University College of Wales, Aberystwyth.
1902. §Sully, H. J. Avalon House, Priory-road, Clifton, Bristol.
1898. §Sully, T. N. Avalon House, Priory-road, Clifton, Bristol.
1884. ‡Sumner, George. 107 Stanley-street, Montreal, Canada.

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Year of Election.

1887. ‡Sumpner, W. E. 37 Pennyfields, Poplar, E.
1888. ‡Sunderland, John E. Bark House, Hatherlow, Stockport.
1883. ‡Sutcliffe, J. S., J.P. Beech House, Bacup.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. Thurso House, Newcastle-upon-Tyne.
1886. ‡Sutherland, Hugh. Winnipeg, Manitoba, Canada.
1892. ‡Sutherland, James B. 10 Windsor-street, Edinburgh.
1884. ‡Sutherland, J. C. Richmond, Quebec, Canada.
1863. ‡Sutton, Francis, F.C.S. Bank Plain, Norwich.
1889. ‡Sutton, William. Esbank, Jesmond, Newcastle-upon-Tyne.
1898. §Sutton, William, M.D. 6 Camden-crescent, Dover.
1891. ‡Swainson, George, F.L.S. North Drive, St. Anne's-on-Sea, Lancashire.
1903. §Swallow, Rev. R. D., M.A. Chigwell School, Essex.
1881. §Swan, Joseph Wilson, M.A., D.Sc., F.R.S. 58 Holland-park, W.
1897. ‡Swanston, William, F.G.S. Mount Collyer Factory, Belfast.
1879. ‡Swanwick, Frederick. Whittington, Chesterfield.
1887. §Swinburne, James, M.Inst.C.E. 82 Victoria-street, S.W.
1870. *Swinburne, Sir John, Bart. Capheaton Hall, Newcastle-upon-Tyne.
1887. *Swindells, Rupert, F.R.G.S. 22 Oxford-road, Birkdale, Southport.
1890. ‡Swinhoe, Colonel C., F.L.S. Avenue House, Oxford.
1873. ‡Sykes, Benjamin Clifford, M.D. St. John's House, Cleckheaton.
1895. ‡Sykes, E. R. 3 Gray's Inn-place, W.C.
1902. *Sykes, Miss Ella C. Elcombs, Lyndhurst, Hampshire.
1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. Glencoe, 64 Elmbourne-road, Tooting Common, S.W.
1896. *Sykes, Mark L., F.R.M.S. Kensington House, Pensford, viâ Bristol.
1902. *Sykes, Major P. Molesworth, C.M.G. Elcombs, Lyndhurst, Hampshire.
1893. ‡Symes, Rev. J. E., M.A. 70 Redcliffe-crescent, Nottingham.
1870. ‡Symes, Richard Glascott, M.A., F.G.S., Geological Survey of Scotland. Sheriff Court-buildings, Edinburgh.
1903. §Symington, Howard W. Brooklands, Market Harborough.
1885. ‡Symington, Johnson, M.D., F.R.S., F.R.S.E. (Pres. H, 1903), Professor of Anatomy in Queen's College, Belfast.
1886. ‡Symons, W. H., M.D. (Brux.), M.R.C.P., F.I.C. Guildhall, Bath.

1896. ‡Tabor, J. M. Holmwood, Harringay Park, Crouch End, N.
1898. ‡Tagart, Francis. 199 Queen's-gate, S.W.
1865. ‡Tallyour, Colonel Renny, R.E. Newmanswalls, Montrose, Forfarshire.
1894. ‡Takakusu, Jyun, B.A. 17 Worcester-terrace, Oxford.
1903. *Tanner, Miss Ellen G. 48 Campden House Court, Gloucester-walk, W.
1890. ‡Tanner, H. W. Lloyd, D.Sc., F.R.S. (Local Sec. 1891), Professor of Mathematics and Astronomy in University College, Cardiff.
1897. ‡Tanner, Professor J. H. Ithaca, New York, U.S.A.
1892. *Tansley, Arthur G., M.A., F.L.S. University College, W.C.
1883. *Tapscott, R. Lethbridge, F.R.A.S. 62 Croxteth-road, Liverpool.
1878. ‡Tarpey, Hugh. Dublin.
1861. *Tarratt, Henry W. Broadhayes, Dean Park, Bournemouth.
1857. *Tate, Alexander. Rantalard, Whitehouse, Belfast.
1893. ‡Tate, George, Ph.D. College of Chemistry, Duke-street, Liverpool.
1902. ‡Tate, Miss. Rantalard, Whitehouse, Belfast.

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Year of Election.

1901. †Taylor, Benson. 22 Hayburn-crescent, Partick, Glasgow.
1884. *Taylor, Rev. Charles, D.D. St. John's Lodge, Cambridge.
1887. §Taylor, G. H. Holly House, 235 Eccles New-road, Salford.
1898. †Taylor, Lieut.-Colonel G. L. Le M. 6 College-lawn, Cheltenham.
1887. †Taylor, George Spratt. 13 Queen's-terrace, St. John's Wood, N.W.
1881. **Taylor, H. A.* 69 *Addison-road, Kensington, W.*
1884. *Taylor, H. M., M.A., F.R.S. Trinity College, Cambridge.
1882. *Taylor, Herbert Owen, M.D. Oxford-street, Nottingham.
1860. *Taylor, John, M.Inst.C.E., F.G.S. 6 Queen Street-place, E.C.
1881. *Taylor, John Francis. Holly Bank House, York.
1865. †Taylor, Joseph. 99 Constitution-hill, Birmingham.
1899. †Taylor, Robert H., Assoc.M.Inst.C.E. 5 Maison Dieu-road, Dover.
1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.
1900. †Taylor, T. H. Yorkshire College, Leeds.
1887. †Taylor, Tom. Grove House, Sale, Manchester.
1883. †Taylor, William, M.D. 21 Crockherbtown, Cardiff.
1901. §Taylor, William. 57 Sparkenhoe-street, Leicester.
1903. §Taylor, William. 61 Cambridge-road, Southport.
1895. †Taylor, W. A., M.A., F.R.S.E. Royal Scottish Geographical Society, Edinburgh.
1893. †*Taylor, W. F. Bhootan, Whitehorse-road, Croydon, Surrey.*
1894. *Taylor, W. W., M.A. 30 Banbury-road, Oxford.
1884. †Taylor-Whitehead, Samuel, J.P. Burton Closes, Bakewell.
1901. *Teacher, John H., M.B. 32 Huntly-gardens, Glasgow.
1858. †Teale, Thomas Pridgin, M.A., F.R.S. 38 Cookridge-street, Leeds.
1885. †Teall, J. J. H., M.A., F.R.S., F.G.S. (Pres. C, 1893; Council 1894–1900), Director of the Geological Survey of the United Kingdom. 89 Thurlow Park-road, West Dulwich, S.E.
1898. §Tebb, Robert Palmer. Enderfield, Chislehurst, Kent.
1879. †Temple, Lieutenant G. T., R.N., F.R.G.S. The Nash, near Worcester.
1889. †*Tennant, James. Saltwell, Gateshead.*
1894. †*Terras, J. A., B.Sc.* 40 *Findhorn-place, Edinburgh.*
1882. †Terrill, William. 42 St. George's-terrace, Swansea.
1896. *Terry, Rev. T. R., M.A., F.R.A.S. The Rectory, East Ilsley, Newbury, Berkshire.
1892. *Tesla, Nikola. 45 West 27th-street, New York, U.S.A.
1883. †Tetley, C. F. The Brewery, Leeds.
1883. †Tetley, Mrs. C. F. The Brewery, Leeds.
1882. *Thane, George Dancer, Professor of Anatomy in University College, Gower-street, W.C.
1889. †Thetford, The Right Rev. A. T. Lloyd, D.D., Bishop of. North Creake Rectory, Fakenham, Norfolk.
1885. †Thin, Dr. George. 22 Queen Anne-street, W.
1871. †Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., M.A., B.Sc., Ph.D., LL.D., F.R.S., F.L.S. (Pres. D, 1888; Pres. K, 1895; Council 1885–89, 1895–1900). Royal Gardens, Kew.
1870. †Thom, Robert Wilson. Lark Hill, Chorley, Lancashire.
1891. †Thomas, Alfred, M.P. Pen-y-lan, Cardiff.
1891. †Thomas, A. Garrod, M.D., J.P. Clytha Park, Newport, Monmouthshire.
1891. *Thomas, Miss Clara. Penurrig, Builth.
1891. †Thomas, Edward. 282 Bute-street, Cardiff.
1891. †Thomas, E. Franklin. Dan-y-Bryn, Radyr, near Cardiff.
1903. §Thomas, Miss E. N. 73 Clyde-road, East Croydon.
1869. †Thomas, H. D. Fore-street, Exeter.
1875. †Thomas, Herbert. Ivor House, Redland, Bristol.

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Year of Election.

1881. ‡Thomas, J. Blount. Southampton.
1869. ‡Thomas, J. Henwood, F.R.G.S. 86 Breakspears-road, Brockley, S.E.
1880. *Thomas, Joseph William, F.C.S. Overdale, Shortlands, Kent.
1899. *Thomas, Mrs. J. W. Overdale, Shortlands, Kent.
1902. §Thomas, Miss M. B. 200 Bristol-road, Birmingham.
1883. ‡Thomas, Thomas H. 45 The Walk, Cardiff.
1898. ‡Thomas, Rev. U. Bristol School Board, Guildhall, Bristol.
1883. ‡Thomas, William. Lan, Swansea.
1886. ‡Thomas, William. 109 Tettenhall-road, Wolverhampton.
1886. ‡Thomason, Yeoville. 9 Observatory-gardens, Kensington, W.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.
1891. *Thompson, Beeby, F.C.S., F.G.S. 67 Victoria-road, Northampton.
1883. ‡Thompson, Miss C. E. Heald Bank, Bowdon, Manchester.
1891. ‡Thompson, Charles F. Penhill Close, near Cardiff.
1882. ‡Thompson, Charles O. Terre Haute, Indiana, U.S.A.
1888. *Thompson, Claude M., M.A., Professor of Chemistry in University College, Cardiff.
1885. ‡Thompson, D'Arcy W., B.A., C.B., Professor of Zoology in University College, Dundee.
1896. *Thompson, Edward P. Paulsmoss, Whitchurch, Salop.
1883. *Thompson, Francis. Lynton, Haling Park-road, Croydon.
1891. ‡Thompson, G. Carslake. Park-road, Penarth.
1893. *Thompson, Harry J., M.Inst.C.E., Madras. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1870. ‡Thompson, Sir Henry, Bart. 35 Wimpole-street, W.
1883. *Thompson, Henry G., M.D. 86 Lower Addiscombe-road, Croydon.
1891. ‡Thompson, Herbert M. Whitley Batch, Llandaff.
1891. ‡Thompson, H. Wolcott. 9 Park-place, Cardiff.
1883. *Thompson, Isaac Cooke, F.L.S., F.R.M.S. (Local Sec. 1896). 53 Croxteth-road, Liverpool.
1897. ‡Thompson, J. Barclay. 37 St. Giles's, Oxford.
1891. ‡Thompson, J. Tatham, M.B. 23 Charles-street, Cardiff.
1861. *Thompson, Joseph. Riversdale, Wilmslow, Cheshire.
1876. *Thompson, Richard. Dringcote, The Mount, York.
1883. ‡Thompson, Richard. Bramley Mead, Whalley, Lancashire.
1876. ‡Thompson, Silvanus Phillips, B.A., D.Sc., F.R.S., F.R.A.S. (Council 1897–99), Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury, E.C.
1883. *Thompson, T. H. Oldfield Lodge, Gray-road, Bowdon, Cheshire.
1896. *Thompson, W. H., M.D. 14 Hatch-street, Dublin.
1896. ‡Thompson, W. P. 6 Lord-street, Liverpool.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1894. ‡Thomson, Arthur, M.A., M.D., Professor of Human Anatomy in the University of Oxford. Exeter College, Oxford.
1889. *Thomson, James, M.A. 22 Wentworth-place, Newcastle-upon-Tyne.
1891. ‡Thomson, John. 70A Grosvenor-street, W.
1896. ‡*Thomson, John.* 3 *Derwent-square, Stonycroft, Liverpool.*
1890. ‡Thomson, Professor J. Arthur, M.A., F.R.S.E. Castleton House, Old Aberdeen.
1883. ‡Thomson, J. J., M.A., D.Sc., F.R.S. (Pres. A, 1896; Council 1893–95), Professor of Experimental Physics in the University of Cambridge. Trinity College, Cambridge.
1871. *Thomson, John Millar, LL.D., F.R.S. (Council 1895–1901), Professor of Chemistry in King's College, London. 85 Addison-road, W.
1902. ‡Thomson, J. Stuart. Marine Biological Laboratory, Plymouth.

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Year of Election.

1901. §Thomson, Dr. J. T. Kilpatrick. 148 Norfolk-street, Glasgow.
1874. §Thomson, William, F.R.S.E., F.C.S. Royal Institution, Manchester.
1880. §Thomson, William J. Ghyllbank, St. Helens.
1897. †Thorburn, James, M.D. Toronto, Canada.
1871. †Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1887. †Thornton, John. 3 Park-street, Bolton.
1898. §Thornton, W. M. The Durham College of Science, Newcastle-on-Tyne.
1902. §Thornycroft, Sir John I., F.R.S., M.Inst.C.E. Eyot Villa, Chiswick Mall, W.
1883. †Thorowgood, Samuel. Castle-square, Brighton.
1903. §Thorp, Edward. 87 Southbank-road, Southport.
1881. †Thorp, Fielden. Blossom-street, York.
1881. *Thorp, Josiah. 37 Pleasant-street, New Brighton, Cheshire.
1898. §Thorp, Thomas. Moss Bank, Whitefield, Manchester.
1898. †Thorpe, Jocelyn Field, Ph.D. Owens College, Manchester.
1871. †Thorpe, T. E., C.B., Ph.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1890; Council 1886–92), Principal of the Government Laboratories, Clement's Inn-passage, W.C.
1883. §Threlfall, Henry Singleton, J.P. 1 London-street, Southport.
1899. §Threlfall, Richard, M.A., F.R.S. 30 George-road, Edgbaston, Birmingham.
1896. §Thrift, William Edward, M.A., Professor of Natural and Experimental Philosophy in the University of Dublin. 80 Grosvenor-square, Rathmines, Dublin.
1868. †Thuillier, General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. Tudor House, Richmond Green, Surrey.
1889. †Thys, Captain Albert. 9 Rue Briderode, Brussels.
1870. †Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.
1873. *Tiddeman, R. H., M.A., F.G.S. 175 Banbury-road, Oxford.
1874. †Tilden, William A., D.Sc., F.R.S., Treas.C.S. (Pres. B, 1888, Council 1898–), Professor of Chemistry in the Royal College of Science, South Kensington, London. The Oaks, Northwood, Middlesex.
1883. †Tillyard, A. I., M.A. Fordfield, Cambridge.
1883. †Tillyard, Mrs. Fordfield, Cambridge.
1896. §Timmis, Thomas Sutton. Cleveley, Allerton, Liverpool.
1899. †Tims, H. W. Marett, B.A., M.D., F.L.S. 10 Bateman-street, Cambridge.
1902. §Tipper, Charles J. R., B.Sc. 6 Beechwood, Kendal.
1900. §Tocher, J. F., F.I.C. 5 Chapel-street, Peterhead, N.B.
1876. †Todd, Rev. Dr. Tudor Hall, Forest Hill, S.E.
1891. †Todd, Richard Rees. Portuguese Consulate, Cardiff.
1897. †Todhunter, James. 85 Wellesley-street, Toronto, Canada.
1889. §Toll, John M. 49 Newsham-drive, Liverpool.
1857. †Tombe, Rev. Canon. Glenealy, Co. Wicklow.
1888. †Tomkins, Rev. Henry George. Park Lodge, Weston-super-Mare.
1896. †*Toms, Frederick.* 1 *Ambleside-avenue, Streatham, S.W.*
1887. †Tonge, James, F.G.S. 24 Hampton-road, Southport.
1865. †*Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.*
1873. *Tookey, Charles, F.C.S. Portland Hotel, Great Portland-street, W.
1875. †Torr, Charles Hawley. St. Alban's Tower, Mansfield-road, Sherwood, Nottingham.
1884. *Torrance, Rev. Robert, D.D. Guelph, Ontario, Canada.
1873. †Townend, W. H. Heaton Hall, Bradford, Yorkshire.

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Year of Election.

1875. ‡Townsend, Charles. St. Mary's, Stoke Bishop, Bristol.
1901. ‡Townsend, J. S. E., M.A., F.R.S., Professor of Physics in the University of Oxford. New College, Oxford.
1876. *Traill, J. W. H., M.A., M.D., F.R.S., F.L.S., Regius Professor of Botany in the University of Aberdeen.
1883. ‡Traill, A., M.D., LL.D. Ballylough, Bushmills, Ireland.
1870. ‡Traill, William A. Giant's Causeway Electric Tramway, Portrush, Ireland.
1868. ‡Traquair, Ramsay H., M.D., LL.D., F.R.S., F.G.S. (Pres. D, 1900), Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh.
1902. ‡Travers, Ernest J. Dunmurry, Co. Antrim.
1891. ‡*Trayes, Valentine. Maindell Hall, Newport Monmouthshire.*
1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.
1868, ‡Trehane, John. Exe View Lawn, Exeter.
1891. ‡Treharne, J. Ll. 92 Newport-road, Cardiff.
1887. *Trench-Gascoigne, Mrs. F. R. Lotherton Hall, Parlington, Aberford, Leeds.
1903. §Trenchard, Hugh. The Firs, Clay Hill, Enfield.
1883. ‡Trendell, Edwin James, J.P. Abbey House, Abingdon, Berkshire.
1884. ‡Trenham, Norman W. 18 St. Alexis-street, Montreal, Canada.
1884. ‡Tribe, Paul C. M. 44 West Oneida-street, Oswego, New York, U.S.A.
1879. ‡Trickett, F. W. 12 Old Haymarket, Sheffield.
1871. ‡Trimen, Roland, M.A., F.R.S., F.L.S., F.Z.S. 26 Campden-grove, Campden Hill, W.
1860. §Tristram, Rev. Henry Baker, D.D., LL.D., F.R.S., Canon of Durham. The College, Durham.
1902. §Tristram, Rev. J. F. 160 Moss-side, Manchester.
1884. *Trotter Alexander Pelham. 8 Richmond-terrace, Whitehall, S.W.
1885. §Trotter, Coutts, F.G.S., F.R.G.S. 10 Randolph-crescent, Edinburgh
1891. ‡Trounce, W. J. 67 Newport-road, Cardiff.
1887. *Trouton, Frederick T., M.A., D.Sc., F.R.S., Professor of Physics in University College, W.C.
1898. §Trow, Albert Howard. Glanhafren, 50 Clive-road, Penarth.
1885. *Tubby, A. H., F.R.C.S. 25 Weymouth-street, Portland-place, W.
1847. *Tuckett, Francis Fox. Frenchay, Bristol.
1888. ‡Tuckett, William Fothergill, M.D. 18 Daniel-street, Bath.
1871. ‡Tuke, Sir J. Batty, M.D., M.P. Cupar, Fifeshire.
1883. ‡Tupper, The Hon. Sir Charles, Bart., G.C.M.G., C.B. Ottawa, Canada.
1892. ‡Turnbull, Alexander R. Ormiston House, Hawick.
1855. ‡Turnbull, John. 37 West George-street, Glasgow.
1901. §Turnbull, Robert. Department of Agriculture and Technical Instruction, Dublin.
1901. ‡Turner, A. Crosbie. 65 Bath-street, Glasgow.
1893. §Turner, Dawson, M.B. 37 George-square, Edinburgh.
1894. *Turner, H. H., M.A., D.Sc., F.R.S., F.R.A.S., Professor of Astronomy in the University of Oxford. The Observatory, Oxford.
1886. *Turner, Thomas, A.R.S.M., F.C.S., F.I.C., Professor of Metallurgy in the University of Birmingham. 35 Wellington-road, Edgbaston, Birmingham.
1863. *Turner, Sir William, K.C.B., LL.D., D.C.L., F.R.S., F.R.S.E. (President, 1900; Pres. H, 1889, 1897), Principal of the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1893. ‡Turney, Sir John, J.P. Alexandra Park, Nottingham.
1890 *Turpin, G. S., M.A., D.Sc. High School, Nottingham.
1886. *Twigg, G. H. 56 Claremont-road, Handsworth, Birmingham.
1898. ‡Twiggs, H. W. 65 Victoria-street, Bristol.

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Year of Election.

1899. ‡Twisden, John R., M.A. 14 Gray's Inn-square, W.C.
1888. ‡Tyack, Llewelyn Newton. University College, Bristol.
1865. §TYLOR, EDWARD BURNETT, D.C.L., LL.D., F.R.S. (Pres. II, 1884; Council 1896–1902), Professor of Anthropology in the University of Oxford. Museum House, Oxford.
1883. ‡Tyrer, Thomas, F.C.S. Stirling Chemical Works, Abbey-lane, Stratford, E.
1897. ‡Tyrrell, J. B., M.A., B.Sc. Ottawa, Canada.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1888. ‡Underhill, H. M. 7 High-street, Oxford.
1886. ‡Underhill, Thomas, M.D. West Bromwich.
1903. §Underwood, Captain J. C. Scarisbrick, New-road, Southport.
1885. §Unwin, Howard. 1 Newton-grove, Bedford Park, Chiswick, W.
1883. §Unwin, John. Eastcliffe Lodge, Southport.
1876. *UNWIN, W. C., F.R.S., M.Inst.C.E. (Pres. G, 1892; Council, 1892–99), Professor of Engineering at the Central Institution of the City and Guilds of London Institute. 7 Palace Gate-mansions, Kensington, W.
1887. ‡Upton, Francis R. Orange, New Jersey, U.S.A.
1872. ‡Upward, Alfred. 150 Holland-road, W.
1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1898. ‡Usher, Thomas. 3 Elmgrove-road, Cotham, Bristol.
1902. §Ussher, R. J. Cappagh House, Cappagh, Co. Waterford.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, S.W.

1885. ‡Vachell, Charles Tanfield, M.D. 38 Charles-street, Cardiff.
1896. ‡Vacher, Francis. 7 Shrewsbury-road, Birkenhead.
1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1903. §Vallack, Edmund. 5 St. Michael's-terrace, Stoke, Devonport.
1888. ‡*Vallentin, Rupert.* 18 *Kimberley-road, Falmouth.*
1884. ‡Van Horne, Sir W. C., K.C.M.G. Dorchester-street West, Montreal, Canada.
1883. *Vansittart, The Hon. Mrs. A. A. Haywood House, Oaklands-road, Bromley, Kent.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, N.
1865. *VARLEY, S. ALFRED. Arrow Works, Jackson-road, Holloway, N.
1903. §Varwell, H. B. 2 Pennsylvania Park, Exeter.
1884. ‡Vasey, Charles. 112 Cambridge-gardens, W.
1895. §Vaughan, D. T. Gwynne. Botanical Laboratory, The University, Glasgow.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1883. ‡Vaughan, William. 42 Sussex-road, Southport.
1881. §VELEY, V. H., M.A., D.Sc., F.R.S. 20 Bradmore-road, Oxford.
1873. *VERNEY, Sir EDMUND H., Bart., F.R.G.S. Claydon House, Winslow, Bucks.
1883. *Verney, Lady. Claydon House, Winslow, Bucks.
1896. *Vernon, Thomas T. Wyborne Gate, Birkdale, Southport.
1896. *Vernon, William. Tean Hurst, Tean, Stoke-upon-Trent.
1864. *VICARY, WILLIAM, F.G.S. The Priory, Colleton-crescent, Exeter.
1890. *Villamil, Lieut.-Colonel R. de, R.E. St. Mary's, Meads-road, Eastbourne.
1899. *VINCENT, SWALE, M.B. Physiological Laboratory, The University, Edinburgh.

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Year of Election.

1883. *Vines, Sydney Howard, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1900; Council, 1894–97), Professor of Botany in the University of Oxford. Headington Hill, Oxford.
1902. §Vinycomb, T. B. Riverside, Holywood, Co. Down.
1891. ‡*Vivian, Stephen. Llantrisant.*

1886. *Wackrill, Samuel Thomas, J.P. 33 Portland-street, Leamington.
1902. ‡Waddell, Rev. C. H. The Vicarage, Saintfield.
1860. ‡Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1900. ‡Waddington, Dr. C. E. 2 Marlborough-road, Manningham, Bradford.
1888. ‡Wadworth, H. A. Breinton Court, near Hereford.
1890. §Wager, Harold W. T., F.L.S. Arnold House, Bass-street, Derby.
1900. ‡*Wagstaff, C. J. L., B.A.* 8 *Highfield-place, Manningham, Bradford.*
1891. ‡Wailes, T. W. 23 Richmond-road, Cardiff.
1902. §Wainwright, Joel. Finchwood, Marple Bridge, Stockport.
1884. ‡Wait, Charles E., Professor of Chemistry in the University of Tennessee. Knoxville, Tennessee, U.S.A.
1886. ‡*Waite, J. W. The Cedars, Bestcot, Walsall.*
1870. ‡Wake, Charles Staniland. Welton, near Brough, East Yorkshire.
1884. ‡Waldstein, Professor C., M.A., Ph.D. King's College, Cambridge.
1891. ‡*Wales, H. T. Pontypridd.*
1891. ‡Walford, Edward, M.D. Thanet House, Cathedral-road, Cardiff.
1894. ‡Walford, Edwin A., F.G.S. 21 West Bar, Banbury.
1882. *Walkden, Samuel, F.R.Met.S. Downside, Whitchurch, Tavistock.
1885. ‡Walker, Mr. Baillie. 52 Victoria-street, Aberdeen.
1893. §Walker, Alfred O., F.L.S. Ulcombe Place, Maidstone, Kent.
1890. ‡Walker, A. Tannett. The Elms, Weetwood, Leeds.
1901. *Walker, Archibald, M.A., F.I.C. 8 Crown-terrace, Glasgow.
1897. *Walker, B. E., F.G.S. (Local Sec. 1897). Canadian Bank of Commerce, Toronto, Canada.
1883. ‡Walker, Mrs. Emma. 13 Lendal, York.
1883. ‡Walker, E. R. 19 Roe-lane, Southport.
1891. ‡Walker, Frederick W. Tannett. Carr Manor, Meanwood, Leeds.
1897. ‡Walker, George Blake. Tankersley Grange, near Barnsley.
1894. *Walker, G. T., M.A. Trinity College, Cambridge.
1866. ‡Walker, H. Westwood, Newport, by Dundee.
1896. ‡Walker, Horace. Belvidere-road, Prince's Park, Liverpool.
1890. ‡Walker, Dr. James. 19 Springfield, Dundee.
1894. *Walker, James, M.A. 30 Norham-gardens, Oxford.
1866. *Walker, J. Francis, M.A., F.G.S., F.L.S. 45 Bootham, York.
1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
1884. ‡Walker, Samuel. Woodbury, Sydenham Hill, S.E.
1888. ‡Walker, Sydney F. Bloomfield-crescent, Bath.
1887. ‡Walker, T. A. 15 Great George-street, S.W.
1883. ‡Walker, Thomas A. 7 Cambridge-road, Southport.
Walker, William. 47 Northumberland-street, Edinburgh.
1895. §Walker, William G., A.M.Inst.C.E. 47 Victoria-street, S.W.
1896. §Walker, Colonel William Hall, M.P. Gateacre, Liverpool.
1896. ‡Walker, W. J. D. Glenhanna, Laurencetown, Co. Down, Ireland.
1883. ‡Wall, Henry. 14 Park-road, Southport.
1863. ‡Wallace, Alfred Russel, D.C.L., F.R.S., F.L.S., F.R.G.S. (Pres. D, 1876; Council 1870–72). Broadstone, Wimborne, Dorset.
1897. ‡Wallace, Chancellor. Victoria University, Toronto, Canada.
1901. §Wallace, James Sim, M.D., D.Sc. 30A Wimpole-street, W.
1892. ‡Wallace, Robert W. 14 Frederick-street, Edinburgh.
1901. ‡Wallace, William, M.A., M.D. 25 Newton-place, Glasgow.

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Year of Election.

1887. *Waller, Augustus D., M.D., F.R.S. 32 Grove End-road, N.W.
1889. *Wallis, Arnold J., M.A. 5 Belvoir-terrace, Cambridge.
1895. ‡Wallis, E. White, F.S.S. Sanitary Institute, Parkes Museum, Margaret-street, W.
1883. ‡Wallis, Rev. Frederick. Caius College, Cambridge.
1884. ‡Wallis, Herbert. 239 Drummond-street, Montreal, Canada.
1886. ‡Wallis, Whitworth, F.S.A. Chevening, Montague-road, Edgbaston, Birmingham.
1894. *Walmisley, A.T., M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1887. ‡Walmsley, J. Monton Lodge, Eccles, Manchester.
1891. §Walmsley, R. M., D.Sc. Northampton Institute, Clerkenwell, E.C.
1903. §Walsh, W. T. H. Toynbee Hall, Whitechapel, E.
1895. ‡Walsingham, The Right Hon. Lord, LL.D., F.R.S. (Vice-President 1904.) Merton Hall, Thetford.
1902. *Walter, Miss L. Edna. 38 Woodberry-grove, Finsbury Park, N.
1881. ‡Walton, Thomas, M.A. Oliver's Mount School, Scarborough.
1884. ‡Wanless, John, M.D. 88 Union-avenue, Montreal, Canada.
1887. ‡Ward, A. W., M.A., Litt.D., Master of Peterhouse, Cambridge.
1881. §Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.
1879. ‡Ward, H. Marshall, D.Sc., F.R.S., F.L.S. (Pres. K, 1897; Council 1890–97), Professor of Botany, University of Cambridge. New Museums, Cambridge.
1890. ‡Ward, Alderman John. Moor Allerton House, Leeds.
1874. §Ward, John, J.P., F.S.A. Lenoxvale, Belfast.
1887. ‡Ward, John, F.G.S. 23 Stafford-street, Longton, Staffordshire.
1857. ‡Ward, John S. Prospect Hill, Lisburn, Ireland.
1880. *Ward, J. Wesney. 4 Chepstow-mansions, Chepstow-place, Bayswater, W.
1887. ‡Ward, Thomas. Brookfield House, Northwich.
1882. ‡Ward, William. Cleveland Cottage, Hill-lane, Southampton.
1867. ‡Warden, Alexander J. 23 Panmure-street, Dundee.
1901. §Wardlaw, Alexander. 21 Hamilton-drive, Hillhead, Glasgow.
1858. ‡Wardle, Sir Thomas, F.G.S. St. Edward-street, Leek, Staffordshire.
1884. ‡Wardwell, George J. 31 Grove-street, Rutland, Vermont, U.S.A.
1887. *Waring, Richard S. Standard Underground Cable Co., 16th-street, Pittsburg, Pennsylvania, U.S.A.
1878. ‡Warington, Robert, F.R.S., F.C.S. High Bank, Harpenden, St. Albans, Herts.
1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.
1896. ‡Warrand, Major-General, R.E. Westhorpe, Southwell, Middlesex.
1887. ‡Warren, Lieut.-General Sir Charles, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. (Pres. E, 1887). Athenæum Club, S.W.
1898. ‡*Warrington, Arthur W. University College, Aberystwith.*
1893. ‡Warwick, W. D. Balderton House, Newark-on-Trent.
1875. *Waterhouse, Major-General J. Oak Lodge, Court-road, Eltham, Kent.
1870. ‡Waters, A. T. H., M.D. 60 Bedford-street, Liverpool.
1900. §Waterston, David, M.D. 23 Colinton-road, Edinburgh.
1892. ‡Waterston, James H. 37 Lutton-place, Edinburgh.
1875. ‡Watherston, Rev. Alexander Law, M.A., F.R.A.S. The Grammar School, Hinckley, Leicestershire.
1884. ‡Watson, A. G., D.C.L. Uplands, Wadhurst, Sussex.
1901. *Watson, Arnold Thomas, F.L.S. Southwold, Tapton Crescent-road, Sheffield.
1886. *Watson, C. J. Alton Cottage, Botteville-road, Acock's Green, Birmingham.

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Year of Election.

1883. ‡Watson, C. Knight, M.A. 49 Bedford-square, W.C.
1892. §Watson, G., Assoc.M.Inst.C.E. 21 Springfield-mount, Leeds.
1885. ‡Watson, Deputy Surgeon-General G. A. Hendre, Overton Park, Cheltenham.
1884. ‡Watson, John. Queen's University, Kingston, Ontario, Canada.
1889. ‡Watson, John, F.I.C. P.O. Box 317, Johannesburg, South Africa.
1863. ‡Watson, Joseph. Bensham-grove, Gateshead.
1863. ‡Watson, R. Spence, LL.D., F.R.G.S. Bensham-grove, Gateshead.
1867. ‡Watson, Thomas Donald. 16 St. Mary's-road, Bayswater, W.
1894. *Watson, Professor W., D.Sc., F.R.S. 7 Upper Cheyne-row, S.W.
1892. §Watson, William, M.D. The Lea, Corstorphine, Midlothian.
1879. *Watson, William Henry, F.C.S., F.G.S. Steelfield Hall, Gosforth, Cumberland.
1882. ‡Watt, Alexander. 29 Grange Mount, Claughton, Birkenhead.
1864. ‡Watt, D. A. P. 284 Upper Stanley-street, Montreal, Canada.
1901. §Watt, Henry Anderson. Ardenslate House, Hunter's Quay, Argyllshire.
1888. ‡Watts, B. H. (Local Sec. 1888). 10 Rivers-street, Bath.
1875. *Watts, John, B.A., D.Sc. Merton College, Oxford.
1884. *Watts, Rev. Canon Robert R. The Red House, Bemerton, Salisbury.
1870. §Watts, William, F.G.S. Little Don Waterworks, Langsett, near Penistone.
1896. ‡Watts, W. H. Elm Hall, Wavertree, Liverpool.
1873. *Watts, W. Marshall, D.Sc. Giggleswick Grammar School, and Carrholme, Stackhouse, near Settle.
1883. *Watts, W. W., M.A., M.Sc., Sec.G.S. (Pres. C, 1903; Council 1902–), Assistant Professor of Geology in the University, Birmingham. Holmwood, Bracebridge-road, Sutton Coldfield.
1891. ‡Waugh, James. Higher Grade School, 110 Newport-road, Cardiff.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1883. ‡*Webb, George.* 5 *Tenterden-street, Bury, Lancashire.*
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
1886. §Webber, Major-General C. E., C.B., M.Inst.C.E. 17 Egerton-gardens, S.W.
1891. §Webber, Thomas. The Laurels, 83 Newport-road, Roath, Cardiff.
1859. ‡Webster, John. Edgehill, Aberdeen.
1884. *Wedekind, Dr. Ludwig, Professor of Mathematics at Karlsruhe. Jahnstrasse 5, Karlsruhe.
1903. §Weekes, R. W. 65 Hayes-road, Bromley, Kent.
1889. ‡Weeks, John G Bedlington.
1890. *Weiss, F. Ernest, D.Sc., F.L.S., Professor of Botany in Owens College, Manchester.
1886. ‡Weiss, Henry. Westbourne-road, Birmingham.
1865. ‡Welch, Christopher, M.A. United University Club, Pall Mall East, S.W.
1902. ‡Welch, R. J. 49 Lonsdale-street, Belfast.
1894. ‡Weld, Miss. Conal More, Norham-gardens, Oxford.
1876. *Weldon, Professor W. F. R., M.A., F.R.S., F.L.S. (Pres. D, 1898). The Museum, Oxford.
1880. *Weldon, Mrs. Merton Lea, Oxford.
1897. ‡Welford, A. B., M.B. Woodstock, Ontario, Canada.
1881. §Wellcome, Henry S. Snow Hill-buildings, E.C.
1879. §Wells, Charles A., A.I.E.E. 219 High-street, Lewes.
1881. §Wells, Rev. Edward, M.A. West Dean Rectory, Salisbury.
1894. ‡Wells, J. G. Selwood House, Shobnall-street, Burton-on-Trent.

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Year of Election.

1883. †Welsh, Miss. Girton College, Cambridge.
1881. *Wenlock, The Right Hon. Lord. Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Roslyn, Walland's Park, Lewes.
1886. *Wertheimer, Julius, B.A., B.Sc., F.C.S., Principal of and Professor of Chemistry in the Merchant Venturers' Technical College, Bristol.
1865. †Wesley, William Henry. Royal Astronomical Society, Burlington House, W.
1853. †West, Alfred. Holderness-road, Hull.
1898. †West, Charles D. Imperial University, Tokyo, Japan.
1853. †West, Leonard. Summergangs Cottage, Hull.
1900. §West, William, F.L.S. 26 Woodville-terrace, Horton-lane, Bradford.
1903. §Westaway, F. W. 1 Pemberley-crescent, Bedford.
1897. †Western, Alfred E. 36 Lancaster-gate, W.
1882. *Westlake, Ernest, F.G.S. Fordingbridge, Salisbury.
1882. †Westlake, Richard. Portswood, Southampton.
1882. †WETHERED, EDWARD B., F.G.S. 4 St. Margaret's-terrace, Cheltenham.
1900. §Wethey, E. R., M.A., F.R.G.S. 4 Cunliffe-villas, Manningham, Bradford.
1885. *WHARTON, Admiral Sir W. J. L., K.C.B., R.N., F.R.S., F.R.A.S., F.R.G.S. (Pres. E, 1894; Council 1890–91), Hydrographer to the Admiralty. Florys, Prince's-road, Wimbledon Park, Surrey.
1884. †Wheeler, Claude L., M.D. 251 West 52nd-street, New York City, U.S.A.
1878. *Wheeler, W. H., M.Inst.C.E. Wyncote, Boston, Lincolnshire.
1888. §Whelen, John Leman. 18 Frognal, Hampstead, N.W.
1893. *WHETHAM, W. C. D., M.A., F.R.S. Upwater Lodge, Cambridge.
1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.
1888. *Whidborne, Miss Constance Mary. Charanté, Torquay.
1879. *WHIDBORNE, Rev. GEORGE FERRIS, M.A., F.G.S. Hammerwood Lodge, East Grinstead, Sussex.
1898. *Whipple, Robert S. Scientific Instrument Company, Cambridge.
1874. †*Whitaker, Henry, M.D. Fortwilliam-terrace, Belfast.*
1883. *Whitaker, T. Walton House, Burley-in-Wharfedale.
1859. *WHITAKER, WILLIAM, B.A., F.R.S., F.G.S. (Pres. C, 1895; Council 1890–96.) 3 Campden-road, Croydon.
1884. †Whitcher, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.
1886. †Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham.
1897. †Whitcombe, George. The Wotton Elms, Wotton, Gloucester.
1886. †*White, Alderman, J.P. Sir Harry's-road, Edgbaston, Birmingham.*
1876. †White, Angus. Easdale, Argyllshire.
1886. †White, A. Silva. 47 Clanricarde-gardens, W.
1898. †White, George. Clare-street House, Bristol.
1882. †White, Rev. George Cecil, M.A. Nutshalling Rectory, Southampton.
1885. *White, J. Martin. Balruddery, Dundee.
1873. †White, John. Medina Docks, Cowes, Isle of Wight.
1883. †White, John Reed. Rossall School, near Fleetwood.
1865. †White, Joseph. 6 Southwell-gardens, S.W.
1895. †White, Philip J., M.B., Professor of Zoology in University College, Bangor, North Wales.
1884. †White, R. 'Gazette' Office, Montreal, Canada.
1898. †White, Samuel. Clare-street House, Bristol.
1859. †White, Thomas Henry. Tandragee, Ireland.
1877. *White, William. 20 Hillersdon-avenue, Church-road, Barnes, S.W.

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Year of Election.

1897. *White, Sir W. H., K.C.B., F.R.S. (Pres. G, 1899; Council 1897–1900). Cedarcroft, Putney Heath, S.W.
1904. §Whitehead, J. E. L., M.A. (Local Secretary 1904). Guildhall, Cambridge.
1883. †Whitehead, P. J. 6 Cross-street, Southport.
1893. §Whiteley, R. Lloyd, F.C.S., F.I.C. 5 Bagnall-street, West Bromwich.
1881. †Whitfield, John, F.C.S. 113 Westborough, Scarborough.
1900. †Whitley, E. N. Heath Royde, Halifax.
1891. §Whitmell, Charles T., M.A., B.Sc. Invermay, Hyde Park, Leeds.
1896. §Whitney, Colonel C. A. The Grange, Fulwood Park, Liverpool.
1897. †Whittaker, E. T., M.A. Trinity College, Cambridge.
1901. §Whitton, James. City Chambers, Glasgow.
1857. *Whitty, Rev. John Irwine, M.A., D.C.L., LL.D. Alpha Villa, Southwood, Ramsgate.
1887. †Whitwell, William. Overdene, Saltburn-by-the-Sea.
1883. †Whitworth, James. 36 Lethbridge-road, Southport.
1870. †Whitworth, Rev. W. Allen, M.A. 7 Margaret-street, W.
1897. †Wickett, M., Ph.D. 339 Berkeley-street, Toronto, Canada.
1888. †Wickham, Rev. F. D. C. Horsington Rectory, Bath.
1865. †Wiggin, Sir H., Bart. Metchley Grange, Harborne, Birmingham.
1886. † *Wiggin, Henry A. The Lea, Harborne, Birmingham.*
1896. †Wigglesworth, J. County Asylum, Rainhill, Liverpool.
1878. †Wigham, John R. Albany House, Monkstown, Dublin.
1889. *Wilberforce, L. R., M.A., Professor of Physics in the University of Liverpool.
1887. †Wild, George. Bardsley Colliery, Ashton-under-Lyne.
1887. *Wilde, Henry, D.Sc., F.R.S. The Hurst, Alderley Edge, Cheshire.
1896. †Wildermann, Meyer. Royal Institution, Albemarle-street, W.
1900. §Wilkinson, J. B. Holme-lane, Dudley Hill, Bradford.
1892. †Wilkinson, Rev. J. Frome., M.A. Barley Rectory, Royston, Herts.
1886. *Wilkinson, J. H. Elmhurst Hall, Lichfield.
1887. *Wilkinson, Thomas Read. Vale Bank, Knutsford, Cheshire.
1872. †Wilkinson, William. 168 North-street, Brighton.
1890. † *Willans, J. W. Kirkstall, Leeds.*
1872. †Willett, Henry (Local Sec. 1872). Arnold House, Brighton.
1903. §Willett, John E. 3 Park-road, Southport.
1894. †Willey, Arthur, D.Sc., F.R.S. The Museum, Colombo, Ceylon.
1891. †Williams, Arthur J., M.P. Coedymwstwr, near Bridgend.
1861. *Williams, Charles Theodore, M.A., M.B. 2 Upper Brook-street, Grosvenor-square, W.
1887. †Williams, Sir E. Leader, M.Inst.C.E. The Oaks, Altrincham.
1883. *Williams, Edward Starbuck. Ty-ar-y-graig, Swansea.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 6 Heathfield, Swansea.
1875. *Williams, Rev. Herbert Addams. Llangibby Rectory, near Newport, Monmouthshire.
1883. †Williams, Rev. H. Alban, M.A. Christ Church, Oxford.
1888. †Williams, James. Bladud Villa, Entry Hill, Bath.
1891. §Williams, J. A. B., M.Inst.C.E. Lingfield Grange, Branksome Park, Bournemouth.
1883. *Williams, Mrs. J. Davies. 5 Chepstow-mansions, Bayswater, W.
1887. †Williams, J. Francis, Ph.D. Salem, New York, U.S.A.
1888. *Williams, Miss Katharine T. Llandaff House, Pembroke-vale Clifton, Bristol.
1875. *Williams, M. B. Killay House, Killay, R.S.O.
1901. *Williams, Miss Mary. 6 Sloane-gardens, S.W.
1891. †Williams, Morgan. 5 Park-place, Cardiff.

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Year of Election.

1886. ‡Williams, Richard, J.P. Brunswick House, Wednesbury.
1883. ‡*Williams, R. Price.* 28 *Compayne-gardens, West Hampstead, N.W.*
1883. ‡Williams, T. H. 27 Water-street, Liverpool.
1877. *Williams, W. Carleton, F.C.S. University College, Sheffield.
1850. *Williamson, Alexander W., Ph.D., LL.D., D.C.L., F.R.S. (President 1873; General Treasurer 1874–91; Pres. B, 1863, 1881; Council 1861–72). High Pitfold, Haslemere.
1857. ‡Williamson, Benjamin, M.A., D.C.L., F.R.S. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1894. *Williamson, Mrs. Janora. Ardoyne, Birkbeck-road, Muswell Hill, N.
1895. ‡Willink, W. (Local Sec. 1896). 14 Castle-street, Liverpool.
1895. ‡Willis, John C., M.A., F.L.S., Director of the Royal Botanical Gardens, Peradeniya, Ceylon.
1896. ‡Willison, J. S. (Local Sec. 1897). Toronto, Canada.
1859. *Wills, The Hon. Sir Alfred. Saxholm, Basset, Southampton.
1898. ‡Wills, H. H. Barley Wood, Wrington, R.S.O., Somerset.
1899. §Willson, George. 12 St. Leonard's-terrace, Streatham, S.W.
1899. §Willson, Mrs. George. 12 St. Leonard's-terrace, Streatham, S.W.
1886. ‡Wilson, Alexander B. Holywood, Belfast.
1901. ‡Wilson, A. Belvoir Park, Newtownbreda, Co. Down.
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. Free Church Manse, North Queensferry.
1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.
1894. *Wilson, Charles J., F.I.C., F.C.S. 14 Old Queen-street, Westminster, S.W.
1903. §Wilson, C. T. R., M.A., F.R.S. Sidney Sussex College, Cambridge.
1874. ‡Wilson, Major-General Sir C. W., R.E., K.C.B., K.C.M.G., D.C.L., F.R.S., F.R.G.S. (Pres E, 1874, 1888). The Athenæum Club, S.W.
1876. ‡Wilson, David. 124 Bothwell-street, Glasgow.
1900. *Wilson, Duncan R. Menethorpe, Malton.
1890. ‡Wilson, Edmund. Denison Hall, Leeds.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, Frederick. 99 Albany-street, N.W.
1903. §Wilson, George. Owens College, Manchester.
1874. *Wilson, George Orr. 20 Berkeley-street, W.
1863. ‡Wilson, George W. Heron Hill, Hawick, N.B.
1895. ‡Wilson, Dr. Gregg. Queen's College, Belfast.
1901. §Wilson, Harold A. Trinity College, Cambridge.
1902. *Wilson, Harry, F.I.C. 146 High-street, Southampton.
1883. *Wilson, Henry, M.A. Farnborough Lodge, Farnborough, R.S.O., Kent.
1879. ‡Wilson, Henry J. 255 Pitsmoor-road, Sheffield.
1885. ‡Wilson, J. Dove, LL.D. 17 Rubislaw-terrace, Aberdeen.
1890. ‡Wilson, J. Mitchell, M.D. 51 Hall-gate, Doncaster.
1865. ‡Wilson, Ven. Archdeacon James M., M.A., F.G.S. The Vicarage, Rochdale.
1884. ‡Wilson, James S. Grant. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1879. ‡Wilson, John Wycliffe. Eastbourne, East Bank-road, Sheffield.
1901. *Wilson, Joseph. Columba Villa, Oban, N.B.
1901. §Wilson, Mrs. Mary R., M.D. Ithaca, New York, U.S.A.
1876. ‡Wilson, R. W. R. St. Stephen's Club, Westminster, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1892 §Wilson, T. Stacey, M.D. 27 Wheeley's-road, Edgbaston, Birmingham.

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Year of Election.

1887. §Wilson, W., jun. Hillocks of Terpersie, by Alford, Aberdeenshire.
1871. *Wilson, William E., D.Sc., F.R.S. Daramona House, Streete, Rathowen, Ireland.
1903. §Wilson-Barker, Captain D., R.N.R., F.R.S.E. Thames Nautical Training College, off Greenhithe, Kent.
1877. ‡Windeatt, T. W. Dart View, Totnes.
1886. ‡Windle, Bertram C. A., M.A., M.D., D.Sc., F.R.S., Professor of Anatomy, The University, Birmingham.
1863. *Winwood, Rev. H. H., M.A., F.G.S. (Local Sec. 1864). 11 Cavendish-crescent. Bath.
1888. ‡Wodehouse, Right Hon. E. R., M.P. 56 Chester-square, S.W.
1875. ‡Wolfe-Barry, Sir John, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1898; Council, 1899–1903). 21 Delahay-street, Westminster, S.W.
1883. ‡Wolfenden, Samuel. Cowley Hill, St. Helens, Lancashire.
1898. ‡Wollaston, G. H. Clifton College, Bristol.
1884. ‡Womack, Frederick, M.A., B.Sc., Lecturer on Physics and Applied Mathematics at St. Bartholomew's Hospital. Bedford College, Baker-street, W.
1883. ‡Wood, Mrs. A. J. 5 Cambridge-gardens, Richmond, Surrey.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1883. ‡Wood, Miss Emily F. Egerton Lodge, near Bolton, Lancashire.
1901. *Wood, Miss Ethel M. 3 Shorncliffe-road, Folkestone.
1875. *Wood, George William Rayner. Singleton, Manchester.
1878. ‡Wood, Sir H. Trueman, M.A. Society of Arts, John-street, Adelphi, W.C.; and 16 Leinster-square, Bayswater, W.
1883. *Wood, J. H. 21 Westbourne-road, Birkdale.
1893. ‡Wood, Joseph T. 29 Muster's-road, West Bridgeford, Nottinghamshire.
1864. ‡Wood, Richard, M.D. Driffield, Yorkshire.
1871. ‡Wood, T. Baileyfield, Portobello, Edinburgh.
1899. *Wood, W. Hoffman. Ben Rhydding, Yorkshire.
1901. *Wood, William James. 266 George-street, Glasgow.
1872. ‡Wood, William Robert. Carlisle House, Brighton.
1845. *Wood, Rev. William Spicer, M.A., D.D. Waldington, Combe Park, Bath.
1884. ‡Woodbury, C. J. H. 31 Milk-street, Boston, U.S.A.
1883. ‡Woodcock, Herbert S. The Elms, Wigan.
1884. ‡Woodd, Arthur B. Woodlands, Hampstead, N.W.
1896. §Woodhead, Professor G. Sims, M.D. Pathological Laboratory, Cambridge.
1888. *Woodiwiss, Mrs. Alfred. Weston Manor, Birkdale, Lancashire.
Woods, Samuel. 1 Drapers'-gardens, Throgmorton-street, E.C.
1887. *Woodward, Arthur Smith, LL.D., F.R.S., F.L.S., F.G.S. (Council 1903–), Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, S.W.
1869. *Woodward, C. J., B.Sc., F.G.S. 127 Metchley-lane, Harborne, Birmingham.
1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, S.W.
1866. ‡Woodward, Henry, LL.D., F.R.S., F.G.S. (Pres. C, 1887; Council, 1887–94). 129 Beaufort-street, Chelsea, S.W.
1870. ‡Woodward, Horace B., F.R.S., F.G.S. Geological Survey Office, Jermyn-street, S.W.
1894. *Woodward, John Harold. 8 Queen Anne's-gate, Westminster, S.W.
1884. *Woolcock, Henry. Rickerby House, St. Bees.
1890. *Woollcombe, Robert Lloyd, M.A., LL.D., F.I.Inst., F.S.S., M.R.I.A., F.R.S.A. (Ireland). 14 Waterloo-road, Dublin.

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Year of Election.

1883. *Woolley, George Stephen. Victoria Bridge, Manchester.
1856. ‡Woolley, Thomas Smith. South Collingham, Newark.
1878. ‡Wormell, Richard, M.A., D.Sc. Roydon, near Ware, Hertfordshire.
1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.
1901. §Worth, J. T. Oakenrod Mount, Rochdale.
1855. *Worthington, Rev. Alfred William, B.A. Old Swinford, Stourbridge.
1884. ‡Wragge, Edmund. 109 Wellesley-street, Toronto, Canada.
1896. ‡Wrench, Edward M., F.R.C.S. Park Lodge, Baslow, Derbyshire.
1883. *Wright, Rev. Arthur, M.A. Queers' College, Cambridge.
1883. *Wright, Rev. Benjamin, M.A. Sandon Rectory, Chelmsford.
1890. ‡Wright, Dr. C. J. Virginia-road, Leeds.
1886. ‡Wright, Frederick William. 4 Full-street, Derby.
1884. ‡Wright, Harrison. Wilkes' Barré, Pennsylvania, U.S.A.
1876. ‡Wright, James. 114 John-street, Glasgow.
1902. §Wright, John. The White House, Burns-street, Nottingham.
1874. ‡Wright, Joseph, F.G.S. 4 Alfred-place, Belfast.
1865. ‡Wright, J. S. 168 Brearley-street West, Birmingham.
1884. ‡Wright, Professor R. Ramsay, M.A., B.Sc. University College, Toronto, Canada.
1876. ‡Wright, William. 31 Queen Mary-avenue, Glasgow.
1903. §Wright, William. The University, Birmingham.
1871. ‡Wrightson, Sir Thomas, Bart., M.P., M.Inst.C.E., F.G.S. Neasham Hall, Darlington.
1898. ‡Wrong, Professor George M. The University, Toronto, Canada.
1902. §Wyatt, G. H. 1 Maurice-road, St. Andrew's Park, Bristol.
1897. ‡Wyld, Frederick. 127 St. George-street, Toronto, Canada.
1901. §Wylie, Alexander. Kirkfield, Johnstone, N.B.
1902. ‡Wylie, John. 2 Mafeking-villas, Whitehead, Belfast.
1885. ‡Wyness, James D., M.D. 349 Union-street, Aberdeen.
1871. ‡Wynn, Mrs. Williams. Plas-yn-Cefn, St. Asaph.
1862. ‡Wynne, Arthur Brevor, F.G.S. Geological Survey Office, 14 Hume-street, Dublin.
1890. ‡Wynne, W. P., D.Sc., F.R.S., Professor of Chemistry to the Pharmaceutical Society of Great Britain. 9 Selwood-terrace, South Kensington, S.W.

1875. ‡Yabbicom, Thomas Henry. 23 Oakfield-road, Clifton, Bristol.
1901. §Yapp, R. H., M.A. Caius College, Cambridge.
*Yarborough, George Cook. Camp's Mount, Doncaster.
1894. *Yarrow, A. F. Poplar, E.
1896. ‡Yates, Rev. S. A. Thompson. 43 Phillimore-gardens, S.W.
1884. ‡Yee, Fung. Care of R. E. C. Fittock, Esq., Shanghai, China.
1877. ‡Yonge, Rev. Duke. Puslinch, Yealmpton, Devon.
1884. ‡York, Frederick. 87 Lancaster-road, Notting Hill, W.
1891. §Young, Alfred C., F.C.S. 53A Algiers-road, Ladywell, S.E.
1886. *Young, A. H., M.B., F.R.C.S. (Local Sec. 1887), Professor of Anatomy in Owens College, Manchester.
1884. ‡Young, Sir Frederick, K.C.M.G. 5 Queensberry-place, S.W.
1894. *Young, George, Ph.D. University College, Sheffield.
1884. ‡Young, Professor George Paxton. 121 Bloor-street, Toronto, Canada.
1876. *Young, John. 2 Montague-terrace, Kelvinside, Glasgow.
1896. ‡*Young, J. Denholm.* 88 *Canning-street, Liverpool.*
1885. ‡Young, R. Bruce. 8 Crown-gardens, Dowanhill, Glasgow.
1901. ‡Young, Robert M., B.A. Rathvarna, Belfast.

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Year of Election.

1883. *Young, Sydney, D.Sc., F.R.S., Professor of Chemistry in the University of Dublin. Trinity College, Dublin.
1887. ‡Young, Sydney. 29 Mark-lane, E.C.
1890. ‡Young, T. Graham, F.R.S.E. Westfield, West Calder, Scotland.
1901. ‡Young, William Andrew. Milburn House, Renfrew.
1903. §Yoxall, J. H., M.P. 67 Russell-square, W.C.

1886. ‡Zair, George. Arden Grange, Solihull, Birmingham.
1886. ‡Zair, John. Merle Lodge, Moseley, Birmingham.

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CORRESPONDING MEMBERS.

Year of Election.

1887. Professor Cleveland Abbe. Weather Bureau, Department of Agriculture, Washington, D.C., U.S.A.
1892. Professor Svante Arrhenius. The University, Stockholm. (Bergsgatan 18).
1881. Professor G. F. Barker. 3909, Locust-street, Philadelphia, U.S.A.
1897. Professor Carl Barus. Brown University, Providence, R.I., U.S.A.
1894. Professor F. Beilstein. 8th Line, No. 17, St. Petersburg.
1894. Professor E. van Beneden. 50 quai des Pêcheurs, Liège, Belgium.
1887. Professor A. Bernthsen, Ph.D. Mannheim, L 11, 4, Germany.
1892. Professor M. Bertrand. 75 rue de Vaugirard, Paris.
1894. Deputy Surgeon-General J. S. Billings. 40 Lafayette-place, New York, U.S.A.
1893. Professor Christian Bohr. Bredgade 62, Copenhagen, Denmark.
1880. Professor Ludwig Boltzmann. XVIII. Haizingergasse 26, Vienna.
1887. Professor Lewis Boss. Dudley Observatory, Albany, New York, U.S.A.
1884. Professor H. P. Bowditch, M.D., LL.D. Harvard Medical School, Boston, Massachusetts, U.S.A.
1890. Professor Dr. L. Brentano. Friedrichstrasse 11, München.
1893. Professor Dr. W. C. Brögger. Universitets Mineralogske Institute, Kristiania, Norway.
1887. Professor J. W. Brühl. Heidelberg.
1884. Professor George J. Brush. Yale University, New Haven, Conn., U.S.A.
1894. Professor D. H. Campbell. Stanford University, Palo Alto, California, U.S.A.
1897. M. C. de Candolle. 3 Cour de St. Pierre, Geneva, Switzerland.
1887. Professor G. Capellini. 65 Via Zamboni, Bologna, Italy.
1887. Hofrath Dr. H. Caro. C. 8, No. 9, Mannheim, Germany.
1894. Emile Cartailhac. 5 Rue de la Chaîne, Toulouse, France.
1861. Professor Dr. J. Victor Carus. Universitätstrasse 15, Leipzig.
1901. Professor T. C. Chamberlin. Chicago, U.S.A.
1894. Dr. A. Chauveau. Rue Cuvier 7, Paris.
1887. F. W. Clarke. United States Geological Survey, Washington, D.C., U.S.A.
1873. Professor Guido Cora. Via Goito 2, Rome.
1889. W. H. Dall. United States Geological Survey, Washington, D.C., U.S.A.
1901. Dr. Yves Delage. Paris.
1872. Professor G. Dewalque. 17 rue de la Paix, Liège, Belgium.
1870. Dr. Anton Dohrn, D.C.L. Naples.
1890. Professor V. Dwelshauvers-Dery. 4 Quai Marcellis, Liège, Belgium.

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Year of Election.

1876. Professor Alberto Eccher. Florence.
1894. Professor Dr. W. Einthoven. Leiden, Netherlands.
1892. Professor F. Elfving. Helsingfors, Finland.
1901. Professor H. Elster, Wolfenbüttel, Germany.
1894. Professor T. W. W. Engelmann, D.C.L. Neue Wilhelmstrasse 15, Berlin, N.W.
1892. Professor Léo Errera. 38 Rue de la Loi, Brussels.
1901. Professor W. G. Farlow. Harvard, U.S.A.
1874. Dr. W. Feddersen. Carolinenstrasse 9, Leipzig.
1886. Dr. Otto Finsch. Leiden, Netherlands.
1887. Professor Dr. R. Fittig. Strassburg.
1894. Professor Wilhelm Foerster, D.C.L. Encke Platz 3A, Berlin, S.W. 48.
1872. W. de Fonvielle. 50 Rue des Abbesses, Paris.
1901. Professor A. P. N. Franchimont. Leiden.
1894. Professor Léon Fredericq. Rue de Pitteurs 20, Liège, Belgium.
1887. Professor Dr. Anton Fritsch. 66 Wenzelsplatz, Prague, Bohemia.
1892. Professor Dr. Gustav Fritsch. Dorotheen Strasse 35, Berlin.
1881. Professor C. M. Gariel. 6 rue Edouard Détaille, Paris.
1866. Dr. Gaudry. 7 bis rue des Saints Pères, Paris.
1901. Professor Dr. Geitel. Wolfenbüttel, Germany.
1884. Professor Wolcott Gibbs. Newport, Rhode Island, U.S.A.
1892. Daniel C. Gilman. Johns Hopkins University, Baltimore, U.S.A.
1870. William Gilpin. Denver, Colorado, U.S.A.
1889. Professor Gustave Gilson. l'Université, Louvain, Belgium.
1889. A. Gobert. 222 Chaussée de Charleroi, Brussels.
1884. General A. W. Greely, LL.D. War Department, Washington, U.S.A.
1892. Dr. C. E. Guillaume. Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres.
1876. Professor Ernst Haeckel. Jena.
1881. Dr. Edwin H. Hall. 37 Gorham-street, Cambridge, Mass., U.S.A.
1895. Professor Dr. Emil Chr. Hansen. Carlsberg Laboratorium, Copenhagen, Denmark.
1887. Fr. von Hefner-Alteneck. Berlin.
1893. Professor Paul Heger. Rue de Drapiers 23, Brussels.
1894. Professor Ludimar Hermann. Universität, Königsberg, Prussia.
1893. Professor Richard Hertwig. Zoologisches Institut, Alte Akademie, Munich.
1893. Professor Hildebrand. Stockholm.
1897. Dr. G. W. Hill. West Nyack, N.Y., U.S.A.
1887. Professor W. His. Königstrasse 22, Leipzig.
1881. Professor A. A. W. Hubrecht, LL.D., C.M.Z.S. The University, Utrecht, Netherlands.
1887. Dr. Oliver W. Huntington. Cloyne House, Newport, R.I., U.S.A.
1884. Professor C. Loring Jackson. 6 Boylston Hall, Cambridge, Massachusetts, U.S.A.
1867. Dr. J. Janssen, LL.D. L'Observatoire, Meudon, Seine-et-Oise.
1876. Dr. W. J. Janssen. Villa Frisia, Aroza, Graubünden, Switzerland.
1881. W. Woolsey Johnson, Professor of Mathematics in the United States Naval Academy. 32 East Preston-street, Baltimore, U.S.A.
1887. Professor C. Julin. 153 rue de Fragnée, Liège.
1876. Dr. Giuseppe Jung. 19 Via Fatebenefratelli, Milan.
1884. Professor Dairoku Kikuchi, M.A. Imperial University, Tokyo, Japan.
1873. Professor Dr. Felix Klein. Wilhelm-Weberstrasse 3, Göttingen.
1894. Professor Dr. L. Kny. Kaiser-Allee 186-7, Wilmersdorf, bei Berlin.
1896. Dr. Kohlrausch. Marchstrasse 25B, and Physikalisch-technische Reichsanstalt, Charlottenburg, Berlin.

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1856. Professor A. von Kölliker. Würzburg, Bavaria.
1894. Professor J. Kollmann. St. Johann 88, Basel, Switzerland.
1894. Maxime Kovalevsky. Beaulieu-sur-Mer, Alpes-Maritimes, France.
1887. Professor W. Krause. Knesebeckstrasse, 17/I, Charlottenburg, bei Berlin.
1877. Dr. Hugo Kronecker, Professor of Physiology. Universität, Bern, Switzerland.
1887. Professor A. Ladenburg. Kaiser Wilhelmstrasse 108, Breslau.
1887. Professor J. W. Langley. 77 Cornell-street, Cleveland, Ohio, U.S.A.
1882. Dr. S. P. Langley, D.C.L., Secretary of the Smithsonian Institution, Washington, U.S.A.
1872. M. Georges Lemoine. 76 Rue Notre Dame des Champs, Paris.
1901. Professor Philipp Lenard. Kiel.
1887. Professor A. Lieben. IX. Wasagasse 9, Vienna.
1883. Dr. F. Lindemann. Franz-Josefstrasse 12/I, Munich.
1877. Dr. M. Lindemann. Sennorrstrasse 62, II, Dresden.
1897. Professor Dr. Georg Lunge. Universität, Zurich.
1871. Professor Jacob Lüroth. Mozartstrasse 10, and Universität, Freiburg-in-Breisgau, Germany.
1894. Professor Dr. Otto Maas. Universität, Munich.
1887. Dr. Henry C. McCook. 3,700 Chestnut-street, Philadelphia, U.S.A.
1867. Professor Mannheim. 1 Boulevard Beausejour, Paris.
1887. Dr. C. A. Martius. Voss Strasse 8, Berlin, W.
1890. Professor E. Mascart, Membre de l'Institut. 176 rue de l'Université, Paris.
1887. Professor D. I. Mendeléeff, D.C.L. Université, St. Petersburg.
1887. Professor N. Menschutkin. St. Petersburg.
1884. Professor Albert A. Michelson. The University, Chicago, U.S.A.
1887. Dr. Charles Sedgwick Minot. Boston, Massachusetts, U.S.A.
1894. Professor G. Mittag-Leffler. Djuvsholm, Stockholm.
1893. Professor H. Moissan. The Sorbonne, Paris (7 Rue Vauquelin).
1877. Professor V. L. Moissenet. 4 Boulevard Gambetta, Chaumont, Hte. Marne, France.
1894. Dr. Edmund von Mojsisovics. Strohgasse 26, Vienna, III/3.
1897. Professor Oskar Montelius. St. Paulsgatan 11, Stockholm, Sweden.
1897. Professor E. W. Morley, LL.D. Adelbert College, Cleveland, Ohio, U.S.A.
1887. E. S. Morse. Peabody Academy of Science, Salem, Mass., U.S.A.
1889. Dr. F. Nansen. Lysaker, Norway.
1894. Professor R. Nasini. Istituto Chimico dell' Università, Padova, Italy.
1864. Dr. G. Neumayer. Deutsche Seewarte, Hamburg.
1884. Professor Simon Newcomb. 1620 P-street, Washington, D.C., U.S.A.
1887. Professor Emilio Noelting. Mühlhausen, Elsass, Germany.
1894. Professor H. F. Osborn. Columbia College, New York, U.S.A.
1894. Baron Osten-Sacken. Heidelberg.
1890. Professor W. Ostwald. Linnéstrasse 2, Leipzig.
1889. Professor A. S. Packard. Brown University, Providence, Rhode Island, U.S.A.
1890. Maffeo Pantaleoni. 20 Route de Malagnou, Geneva.
1895. Professor F. Paschen. Universität, Tübingen.
1887. Dr. Pauli. Feldbergstrasse 49, Frankfurt a/Main, Germany.
1901. Professor A. Penck. Vienna.
1890. Professor Otto Pettersson. Stockhoms Hogskola, Stockholm.
1894. Professor W. Pfeffer, D.C.L. Linnéstrasse 11, Leipzig.

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1870. Professor Felix Plateau. 152 Chaussée de Courtrai, Gand, Belgium.
1886. Professor F. W. Putnam. Harvard University, Cambridge, Massachusetts, U.S.A.
1887. Professor Georg Quincke. Hauptstrasse 47, Friederichsbau, Heidelberg.
1868. L. Radlkofer. Professor of Botany in the University of Munich. Sonnenstrasse 7.
1895. Professor Ira Remsen. Johns Hopkins University, Baltimore, U.S.A.
1897. Professor Dr. C. Richet. 15 Rue de l'Université, Paris, France.
1873. Professor Baron von Richthofen. Kurfürstenstrasse 117, Berlin, W.
1896. Dr. van Rijckevorsel. Parklaan 3, Rotterdam, Netherlands.
1892. Professor Rosenthal, M.D. Erlangen, Bavaria.
1890. A. Lawrence Rotch. Blue Hill Observatory, Readville, Massachusetts, U.S.A.
1895. Professsr Karl Runge. Kaiser Wilhelmstrasse 5, Kirchrode, bei Hannover.
1901. Gen.-Major Rykatchew. Central Physical Observatory, St. Petersburg.
1894. Professor P. H. Schoute. The University, Groningen, Netherlands.
1874. Dr. G. Schweinfurth. Potsdamerstrasse 75A, Berlin.
1897. Professor W. B. Scott. Princeton, N.J., U.S.A.
1892. Dr. Maurits Snellen, Chief Director of the Royal Meteorological Institute of the Netherlands, de Bilt, near Utrecht.
1887. Professor H. Graf Solms. Botanischer Garten, Strasburg.
1887. Ernest Solvay. 25 Rue du Prince Albert, Brussels.
1888. Dr. Alfred Springer. 312 East 2nd-street, Cincinnati, Ohio, U.S.A.
1889. Professor G. Stefanescu. Strada Verde 8, Bucharest, Roumania.
1881. Dr. Cyparissos Stephanos. The University, Athens.
1894. Professor E. Strasburger. The University, Bonn.
1881. Professor Dr. Rudolf Sturm. Fränkelplatz 9, Breslau.
1887. Dr. T. M. Treub. Buitenzorg, Java.
1887. Professor John Trowbridge. Harvard University, Cambridge, Massachusetts, U.S.A.
Arminius Vámbéry, Professor of Oriental Languages in the University of Pesth, Hungary.
1890. Professor Dr. J. H. van't Hoff. Uhlandstrasse 2, Charlottenburg, Berlin.
1889. Wladimir Vernadsky. Mineralogical Museum, Moscow.
1886. Professor Jules Vuylsteke. 21 rue Belliard, Brussels, Belgium.
1887. Professor H. F. Weber. Zurich.
1887. Professor Dr. Leonhard Weber. Moltke Strasse 60, Kiel.
1887. Professor August Weismann. Freiburg-in-Breisgau, Baden.
1887. Dr. H. C. White. Athens, Georgia, U.S.A.
1881. Professor H. M. Whitney. Branford, Conn., U.S.A.
1887. Professor E. Wiedemann. Erlangen. (C/o T. A. Barth, Johannisgasse, Leipzig.)
1887. Professor Dr. R. Wiedersheim. Hansastrasse 3, Freiburg-im-Breisgau, Baden.
1887. Dr. Otto N. Witt. 21 Siegmundshof, Berlin, N.W. 23.
1876. Professor Adolph Wüllner. Aureliusstrasse 9, Aachen.
1887. Professor C. A. Young. Princeton College, New Jersey, U.S.A.
1896. Professor E. Zacharias. Botanischer Garten, Hamburg.
1887. Professor F. Zirkel. Thalstrasse 33, Leipzig.

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